Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks	)	ET Docket No. 08-59
	)	
To: The Commission	)	

COMMENTS OF THE BOEING COMPANY

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SUMMARY

The Commission should not adopt a spectrum allocation for Medical Body Area Networks ("MBANs") in the 2360-2390 MHz band, which is currently allocated on a primary basis for Aeronautical Mobile Telemetry ("AMT") flight test operations. The Commission has repeatedly recognized that flight testing is a "safety-of-life" service that serves important public interest and public safety benefits. Flight test operations push aircraft systems and structures to their operational limits and place flight crews at substantial, yet controlled, risk. AMT signals in the 2360-2390 MHz band are necessary to safely and efficiently monitor these aircraft during flight test maneuvers.

As the Commission has also acknowledged, the flight test process is critically time sensitive, resulting in substantial costs if flight tests are delayed or must be repeated – costs that are inevitably borne by taxpayers or the flying public and impact the competitiveness of the U.S. aviation industry in the global marketplace. Aircraft manufacturers therefore must have flexibility to conduct flight test operations at new and temporary test locations throughout the United States, and to relocate such operations at short notice due to weather conditions, conflicts in schedule and spectrum use involving flight tests on other aircrafts, and other program-specific requirements.

To avoid expensive delays in flight test operations, Boeing employs both fixed AMT receive stations and mobile AMT receive vehicles, both using highly directional tracking antennas to receive the telemetry signals being transmitted from the aircraft under test throughout its authorized area of operation. The mobile vehicles are used to supplement fixed sites and to create short notice temporary AMT test sites anywhere in the United States to take advantage of favorable weather and other conditions. Existing

and temporary test locations should not be constrained by the imposition of spectrum sharing obligations, such as exclusion zones, that would significantly impair the flexibility of aircraft manufacturers.

The Commission should also refrain from taking any action that could limit the airspace available for flight test operations at individual test locations. Boeing's AMT receivers regularly track and monitor the signals of test aircraft at distances of up to 200 miles. The reception of signals at such distances is necessary to ensure that aircraft can conduct flight test maneuvers at high rates of speed (as required by test protocols), often reaching airspeeds of 600 miles per hour (for commercial aircraft) and 1,300 miles per hour (for military aircraft). Any reduction in the reception and reach of AMT receivers would prevent Boeing from completing the necessary collection of data for individual flight tests before aircraft travelling at high speeds exceed the reception area of AMT facilities.

The Commission appears to have recognized that MBANs would cause harmful interference to AMT receivers. The Commission also recognizes that the proposed contention based protocol would not protect AMT receive antennas from harmful interference. The interference mitigation measures proposed in the NPRM, however, would be wholly inadequate to protect AMT operations.

It is not possible for the Commission to establish effective exclusion zones because they would have to be large enough to protect AMT reception under a worst case analysis, they could not protect mobile and temporary AMT antennas, and they would not be enforceable by the Commission.

Further, an indoor use restriction imposed on MBANs would not prevent harmful interference to primary AMT operations if MBANs were located in certain areas of healthcare facilities. Such a restriction also would not be enforceable because hospital patients could "check themselves out" with multiple small, disposable MBANs still attached to their persons. Frequency coordination would also be inappropriate and ineffective in protecting AMT operations.

The Commission should therefore refrain from adopting any spectrum allocation for MBANs in the 2360-2390 MHz band. Although the NPRM tentatively concludes that allocating spectrum for MBANs would serve the public interest, the NPRM is absent of any acknowledgement of the Commission's longstanding recognition of the important public interest and public safety benefits of flight test operations. The 2360-2390 MHz band is used for aircraft test operations that ensure the safety of the flying public and the economic health of the U.S. aviation industry. The Commission should not impose spectrum sharing requirements on the 2360-2390 MHz band that will inevitably harm flight test operations and jeopardize the important public interest benefits that they achieve.

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The Boeing Company ("Boeing"), by its attorneys and pursuant to Section 1.415 of the Commission's Rules, 47 C.F.R. § 1.415, hereby submits the following comments in response to the Notice of Proposed Rulemaking in the above referenced proceeding.[1] The Commission should not establish a secondary allocation for Medical Body Area Networks ("MBANs") in the 2360-2390 MHz band currently used by Boeing and others on a primary basis for Aeronautical Mobile Telemetry ("AMT").

The Commission has previously established the public interest benefits and safety-of-life requirements of flight test operations. These public interest benefits are not outweighed by the proposal to permit MBAN devices to operate in the 2360-2390 MHz band. The interference concerns between flight test operations and MBAN devices are too great and cannot be addressed effectively by mitigation measures such as exclusion zones around AMT testing areas due to the need for mobility and flexibility for safe, effective and efficient AMT flight testing.

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[1] *See Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks*, ET Docket No. 08-59, Notice of Proposed Rulemaking, 24 FCC Rcd 9589, FCC 09-57 (rel. June 29, 2009) ("MBANs NPRM").

I. INTRODUCTION

Boeing is participating in this proceeding as a global leader in the design and manufacture of commercial and military aircraft, as one of the world's largest aerospace and defense contractors, and as a leader in the manufacture and launch of commercial and government satellites. Headquartered in Chicago, Boeing employs more than 158,000 people across the United States and in seventy countries, and is one of the leading U.S. exporters with total revenue in 2008 of $60.9 billion. Boeing is comprised of two major divisions, Boeing Commercial Airplanes ("BCA") and Integrated Defense Systems ("IDS"). Both divisions routinely conduct flight test operations as a critical element of their businesses.

Boeing's AMT flight test operations in the 2360-2390 MHz band are conducted to develop and refine design concepts, to demonstrate compliance with internal design criteria and government regulatory requirements, to evaluate product improvements, to demonstrate operational effectiveness and to ensure compliance with the certification requirements of the Federal Aviation Administration ("FAA"), international and foreign aeronautical regulatory agencies and U.S. government customers. Because flight testing impacts the safety of pilots, passengers and those on the ground, the Commission has consistently stated that flight testing is a safety-of-life application. AMT flight testing requires access to adequate spectrum without harmful interference in a noise-limited environment. As a matter of public policy, the Commission should not allocate the same spectrum to two safety-of-life applications due to the harmful interference that is certain to result.

II. AERONAUTICAL FLIGHT TESTING IS A CRITICAL SAFETY-OF-LIFE SERVICE THE PROTECTION OF WHICH PROMOTES THE PUBLIC INTEREST AND PUBLIC SAFETY

Aeronautical flight tests push each aircraft to its operational and safety limits, subjecting flight crews to substantial, yet controlled risk when adequately monitored in real-time. Safety hazards of certain flight tests are high, particularly those that exercise airplane systems and structures at or near their design envelope, including flight flutter testing, initial airworthiness testing, flight loads surveys and flight controls demonstration (all explained in more detail below). These tests are conducted in FAA-approved airspace, have minimum crew on board (generally only a test pilot and co-pilot), and are accompanied by one or more chase airplanes with crew that visually monitor the exterior of the test airplane while maintaining radio contact with the pilot and co-pilot.

During testing, flight test design engineers monitor the airplane's status from a "telemetry" room on the ground, often hundreds of miles from the aircraft. Data providing the current status of airplane systems and structures is delivered to the room via the AMT data link as rapidly as it is acquired from the instrumentation installed on the airplane. A Test Director in the telemetry room provides test operational instructions and continuous feedback about the airplane's status to the pilot and co-pilot.

The safety of the flight crew depends upon the real-time data received from the aircraft using AMT spectrum. For example, during an initial airworthiness test, the analysts and engineers rely on the real-time data received via the AMT data link to determine the aircraft's current status and whether the aircraft is safe to continue the flight and initiate a subsequent test. If the AMT signal is interfered with, the ground crew may not be able to alert the flight crew in time to avoid or correct a dangerous situation that could result in significant aircraft structural damage to the hull, wing, tail, or other critical components. To illustrate the potential risks involved, the picture below shows tail damage that an E-6 test plane sustained during a high-risk flutter test.

Airplane Damaged During Flutter Test Lands Safely at Boeing Field

When such incidents occur, telemetry room personnel rely on an uninterrupted stream of real time telemetry data to monitor airplane systems for direct and collateral damage. Based on this data, they provide instructions to the pilot and co-pilot to avoid further damage to the airworthiness of the aircraft. As with the E-6 incident, the telemetry data was needed to bring the flight crew and airplane to a safe landing with no further incident or risk to the public on the ground.

The Commission has repeatedly recognized flight testing as a safety-of-life service. Almost twenty years ago, the Commission stated that "[w]e have previously determined that aeronautical flight test and telemetry operations should not share spectrum with unlicensed devices because of the threat to safety of life."[2] The Commission cited to its decision the previous year to prohibit the operation of Part 15 intentional radiators on frequencies used by certain sensitive radio services.[3] In that decision, the Commission described the sensitive radio services as those "involving safety-of-life."[4] The restricted bands used by safety-of-life services included the 2310-2390 MHz band used by aeronautical flight test telemetry.[5]

The Commission has also restricted secondary use of flight test spectrum for other services, such as air show communication, because of the harmful interference that could occur to aircraft being tested "at high altitudes hundreds of miles from their base."[6] The Commission determined that the resulting interference could "directly affect the safe

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[2] *Inquiry Relating to Preparation for the International Telecommunication Union World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum*, Gen Docket No. 89-554, Second Notice of Inquiry, 5 FCC Rcd 6046, 6061, ¶ 102 (1990) (*citing Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License,* Gen Docket No. 87-389, RM-5193, RM-5250, RM-5575, First Report and Order, 4 FCC Rcd 3493, 3502, ¶61 (1989) ("Part 15 First Report and Order")).

[3] Part 15 First Report and Order, 4 FCC Rcd at 3502, ¶ 61.

[4] *Id*.

[5] *Id.* at 3504, ¶ 66.

[6] *Petition to Amend Part 87 of the Commission's Rules to Allot VHF Aeronautical Frequencies for the Coordination of Air Show Events*, RM-7164, Order, 5 FCC Rcd 4641, 4642, ¶ 7 (1990).

operation of such aircraft" and concluded that secondary use of the frequencies "would impair the efficiency and safety of the flight test industry."[7]

The recognized risks of interference from secondary uses to the efficient and safe operation of flight testing have heightened in recent years. Flight test maneuvers have become more sophisticated and far greater amounts of data must be collected in real time to protect the safety of the flight crew and efficiently bring aircraft to market. Further, test aircraft are generally flown at significant speeds and require maneuvering room, necessitating large and varied geographic areas for flight test operations.

The Commission should not require a primary safety-of-life service to operate in the same band with a secondary application, particularly one that effectively provides a safety-of-life service. In the case of the Wireless Medical Telemetry Service ("WMTS"), the Commission recognized the problems inherent in providing a secondary and unlicensed allocation for a safety-of-life service such as WMTS, which is similar to MBANs. The frequencies used by WMTS on a secondary basis became increasingly crowded and the Commission decided to impose restrictions on primary services in the bands. The Commission specifically recognized that:

> Despite the fact that medial telemetry has no legal protection from interference in these bands, the fact remains that the Commission has had to take steps to protect medical telemetry from interference because it is used to protect safety of life. The steps the Commission has taken, such as the freeze in the 450-470 MHz band and the requirement for DTV stations to notify nearby health care facilities, affect other parties.[8]

[7] *Id*.

[8] *See Amendment of Parts 2 and 95 of the Commission's Rules to Create a Wireless Medical Telemetry Service*, ET Docket No. 99-255, PR Docket No. 92-235, Report and Order, 15 FCC Rcd 11206, 11225, ¶ 57 (2000) ("WMTS Order").

As a result, the Commission allocated the 608-614 MHz, 1395-1400 MHz and 1429-1432 MHz bands for WMTS operation on a primary basis.[9] The Commission recognized that safety-of-life medical telemetry applications should not operate on a secondary basis because the inherent need to protect such services forced the Commission to encumber the operations of primary services in the band.

The Commission should not repeat the same mistake with respect to MBANs. In order to enable the long term viability of MBANs, the Commission should identify a spectrum allocation where MBANs can operate on a primary basis, rather than authorize the operation of MBANs on a secondary basis in a spectrum band where harmful interference concerns are substantial.

In this regard, the NPRM appears to be critically unbalanced. The NPRM takes "due notice" of the benefits that could be achieved by allocating spectrum for MBANs, tentatively concluding that providing spectrum for MBANs would serve the public interest.[10] The NPRM, however, is devoid of any reference to the Commission's longstanding recognition of the important and growing public interest benefits (and public safety benefits) that are achieved by flight test operations in the 2360-2390 MHz band. The NPRM states only that "we also recognize the necessity of affording interference protection to incumbent primary users, particularly AMT operations, if MBAN operations are to be permitted in the 2360-2400 MHz band."[11]

[9] *See id*. at 11210, ¶ 11.

[10] *See* MBANs NPRM, 24 FCC Rcd at 9592, 9596, ¶¶ 10, 20.

[11] *Id.*, at 9596, ¶ 20.

In order to afford adequate interference protection to AMT flight test operations, the Commission must consider fully the geographic and spectrum requirements for safe and effective flight test operations. As the Commission has recognized, the spectrum needs of flight test telemetry operations continue to expand in terms of bandwidth requirements, noise floor limitations and geographic reach. Therefore, it would be inappropriate to force these two safety-of-life applications into a spectrum sharing situation that would have to be substantially revisited in the years to come in order to preserve the public interest and public safety benefits that flight test operations provide.

III. AIRCRAFT MANUFACTURERS REQUIRE EXPANDING GEOGRAPHIC REACH AND FLEXIBILITY TO COMPLY WITH THE TIMING AND OPERATIONAL REQUIREMENTS OF MULTIPLE AND DIVERSE FLIGHT TEST OPERATIONS

Flight testing is designed to be, and must be, as efficient as possible. This is because flight testing is conducted at the end of the lengthy and critical certification path that culminates with the delivery of an aircraft. Every day of delay in a flight test program can potentially cost millions of dollars.

To optimize efficiency, aircraft manufacturers must have flexibility with regard to the locations used to perform flight test operations, and Boeing has designed its AMT operations to be capable of testing anywhere in the United States. For example, during a current flight test program concerns have been raised about program overlap with another competing flight test program. As a result, testing will be conducted simultaneously in two separate locations to enable both programs to receive required U.S. Government certification as quickly as possible. In another example, Boeing abruptly moved the AMT base of operations from the central United States to the west coast to address program concerns.

The Commission has specifically recognized the need for AMT flexibility and the costs of delays in flight testing. The Commission has further recognized that the rigorous requirements of flight test operations would make spectrum sharing with a secondary service difficult, observing "sharing of these frequencies with unlike services is difficult at best because schedules of telemetry flight tests are unpredictable and delays costly."[12]

Costs of flight testing delays start at approximately $50,000 per hour and increase exponentially depending on the size and length of the test. Each additional day of delay to complete and secure type certification for an aircraft can cost millions of dollars in inventory costs, labor expenses and delivery penalties. Such increased costs are eventually borne by taxpayers (with respect to government aircraft), the flying public and the nation's overall economy and detract from the global competitiveness of U.S. aerospace manufacturers in the international marketplace. Therefore, the Commission should ensure that aircraft manufacturers such as Boeing are not prevented from continuing to employ flexible measures, such as the use of mobile AMT base vehicles, to conduct flight test operations on a safe and efficient basis.

A. Aircraft Manufacturers Must Be Permitted to Continue to Employ Mobile AMT Base Vehicles at Locations Throughout the United States

In order to enhance the flexibility and responsiveness of Boeing's flight test operations, Boeing maintains fixed AMT receive stations that operate in the 2360-2390

[12] *Amendment of the Frequency Allocation and Aviation Services Rules (Parts 2 and 87) to Provide Frequencies for Use by Commercial Space Launch Vehicles*, Gen. Docket No. 89-89-16, RM-6423, Report and Order, 5 FCC Rcd 493, 495 (1990).

MHz band at sites throughout the United States.[13] Although Boeing uses these fixed sites on a regular basis, it has become increasingly evident these sites are inadequate and Boeing must regularly supplement these sites with mobile AMT base vehicles and antennas that can be used to establish temporary AMT test sites anywhere in the United States.[14]

Boeing therefore owns seven mobile AMT base vehicles that are stationed throughout the United States and additionally employs mobile AMT base vehicles owned by the U.S. government. For example, the mobile trailer and antenna shown below is currently being utilized by IDS's St. Louis, Missouri Test Data Operations team in Palmdale, California to support the test program for the F-15 Singapore aircraft.[15] The St. Louis Test Data Operations team's mobile trailer also supports the F-18 and other proprietary projects and is scheduled for future use at various locations throughout the country.

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[13] Boeing currently conducts flight tests using fixed AMT antennas at Seattle, Washington; Naval Air Station Patuxent River, Maryland; Roswell, New Mexico; Palmdale, California; Moses Lake, Washington; Glasgow, Montana; Naval Air Station China Lake, California; Yuma, Arizona; Mesa, Arizona; Philadelphia, Pennsylvania; St. Louis, Missouri; Edwards Air Force Base, California; and Eglin Air Force Base, Florida. Many of the initial flight tests conducted by Boeing's IDS division occur at Boeing's production sites in areas such as St. Louis, Philadelphia and Mesa, Arizona. Depending on the customer and the type of tests involved, such aircraft then are often tested further at military bases and government test ranges across the United States.

[14] Both BCA and IDS utilize mobile AMT vehicles to support flight testing operations. Boeing's IDS division maintains a Mobile Telemetry Trailer and Portable Antenna that comprises its Mobile Telemetry System. The Mobile Telemetry System can support a single flying aircraft with a separate communication, video and display system. It receives S-band and L-band transmissions, converts them to scaled data and displays them using the SYMVIONICS IADS display software for both classified and unclassified aircraft data systems.

[15] *See* News Release, Boeing Rolls Out 1st F-15SG to Singapore, *available at* http://www.boeing.com/news/releases/2008/q4/081103b_nr.html.

Mobile Telemetry Trailer

Portable Antenna

BCA also has mobile vans that are used to act as stand-alone AMT flight test systems and to supplement existing AMT test ranges, pictured below.

Mobile Station for Telemetry Communications

For example, when BCA was testing the 757-300, the flight test plan, or "critical path" indicated that flight testing would be conducted in Seattle, but the location had to be changed to address ongoing weather problems in the Pacific Northwest. Calm air was needed for a flutter test. Appropriate weather conditions existed in Roswell, New Mexico, so a mobile telemetry van was used in Roswell to conduct the telemetry testing. The late shift in test location helped to maintain the development schedule for the aircraft at significant cost savings.

In addition, some of the AMT testing of the 747-8 Freighter may take place at a new flight test site in Othello, Washington because of flight test range availability issues stemming from the simultaneous flight testing of the 747-8, the 787 Dreamliner, and the P-8A Poseidon. Boeing is currently applying for the authorizations necessary to conduct these flight tests, but this emphasizes the complex nature of scheduling and conducting flight testing.

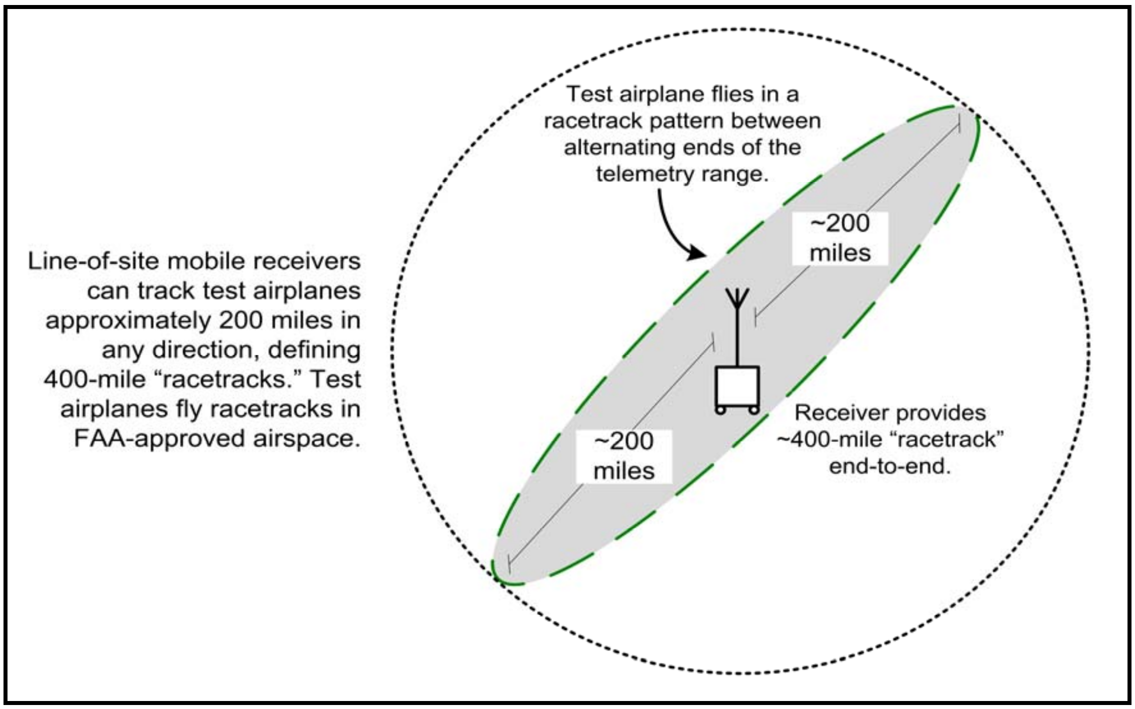
The flexibility afforded by mobile AMT trailers allows Boeing to test its aircraft in varying weather conditions, including wind and extreme temperatures (e.g., deserts), and over different terrain and elevations. This flexibility and mobility is necessary for adequate and efficient flight test operations in varied situations and is required for certification. As discussed in further detail below, it also means that MBANs cannot avoid interference to AMT simply by not operating in exclusion zones around currently active AMT flight test sites. The growing demands of increased and more extensive flight test operations necessitate that aircraft manufacturers not be confined to the *status quo*. Rather, they must be able to employ flight test spectrum in increasing geographic locations to comply efficiently with the production demands of the aviation industry and the regulatory requirements of global aviation authorities.

B. Boeing Must Also Be Permitted to Ensure That Certain Flight Test Locations Have an Effective Radius of at Least 200 Miles

Commercial aircraft are often tested by Boeing at airspeeds in excess of 600 mph. This is necessary because certain flight tests require Boeing to operate aircraft at or above the maximum operating airspeed and designed dive speed of the airplane.[16] When a military aircraft or missile is tested, test speeds often reach Mach 2 (more than 1,300 mph).

[16] The maximum operating speed is defined as the maximum airspeed at which an airline is allowed to operate the airplane. The dive speed is the maximum airspeed that an airframe can be expected to experience in service.

An aircraft flying at 600 mph at an altitude of 31,000 feet covers a 400 mile flight test range in only 35 minutes, and an aircraft traveling at Mach 2 at an altitude of 30,000 to 50,000 feet can cover a 400 mile test area in 18 minutes or less. Once the airplane is out of telemetry range or the telemetry signal is lost, testing must be stopped and cannot resume until the aircraft is back within range and the AMT link can be re-established. A typical BCA telemetry extended range "racetrack" can be seen in the following figure showing the capabilities of highly directional tracking antennas.



Long-Range Telemetry Racetrack

In order to attain an effective flight test racetrack of 400 miles, Boeing has invested in very sensitive receivers that enable engineers to track the airplane approximately 200 miles away from the line-of-site of the mobile or fixed receiver. Boeing's AMT receive antennas include 1.8 meter in diameter antennas that have a gain of 29.1 dBi and additional antennas of up to 4.3 meters in diameter that have a gain of up to 38 dBi.

Although Boeing's AMT receivers are generally capable of receiving the signal of an aircraft up to 200 miles away, Boeing is rarely able to test an aircraft during the entire 400 mile length of a test racetrack. This is because, in most instances, the test aircraft is not generally permitted to fly directly over the AMT receiver, which is often located at an airport or in a populated area. Instead, the aircraft generally flies in a straight line, the closest point of which may be 75 or 100 miles from the AMT receiver.

Additional losses in flight test area frequently result from AMT signal fade caused by such factors as aircraft maneuvers (banking and descending) that alter the aircraft antenna pattern and relative position of the aircraft antenna to the receive antenna. In addition, multipath (i.e., signal loss due to signal reflections) is increased when the flight test occurs over water or melting snow and can further reduce the link's margin. As a result of such geographic and spectrum propagation limitations, Boeing's effective racetrack test area is often reduced, limiting the effective area and time within which test data can be collected.

To preserve effective flight test areas, the Commission should not permit the introduction of a secondary use in the band that inhibits the reception of aircraft telemetry signals to AMT receivers. Any increase in the noise floor resulting from the addition of such services could cause significant interference to test aircraft flying at distances of up to 200 miles from AMT receivers, and could also cause significant harmful interference to aircraft flying at significantly lesser distances, effectively preventing Boeing from completing important flight test operations.

C. The Maintenance of a 400 Mile Test Racetrack Necessitates the Preservation of the Existing Low Noise Floor Environment in the 2360-2390 MHz Band

Boeing and other aircraft manufacturers engaged in AMT flight testing rely on noise limited (not interference limited) conditions in the 2360-2390 MHz band to maintain signal lock with test aircraft. Despite claims to the contrary, the current noise floor in the 2360-2390 MHz band satisfies this requirement. A recent comprehensive series of measurements that were conducted at the Boeing facilities in Seattle identified an average noise floor of -148 dBm.[17]

Boeing selected its facilities in Seattle as the location to take these measurements because its facilities are located in a heavily industrialized area that is immediately adjacent to residential and urban areas. Based on the results of Boeing's study, it can be concluded that the noise floors in the 2360-2390 MHz band in most other regions of the country are at appreciably lower levels.

It has been suggested that AMT receivers successfully operate despite significant spurious out-of-band emissions into the 2360-2400 MHz band, particularly from Part 15 unlicensed devices operating in the adjacent 2400-2483 MHz band.[18] As the Commission recognizes, Part 15 devices do contribute to the noise floor in the 2390-2400 MHz band and, as a result, the upper band edge is sparsely used by AMT operations.[19]

In stark contrast, the existing noise levels in the 2360-2390 MHz band are very low and maintenance of this low noise level is necessary to conduct AMT operations in

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[17] *See* Seattle S-Band Noise Floor Measurements included as an Exhibit.

[18] *See* GEHC Ex Parte, ET Docket No. 08-59 at 1 (filed Oct. 30, 2008).

[19] *See* MBANs NPRM, 24 FCC Rcd at 9594, ¶ 15.

the band. Any increase in the existing noise floor would reduce the available flight test range. As Boeing has explained above, a full 400 mile racetrack is necessary to conduct safe and reliable flight test operations. The Commission therefore should not introduce a secondary service into the 2360-2390 MHz band given the significant impact on the noise floor that would result. Such harmful interference could jeopardize the safety of the flight crew or, at the least, delay the flight testing program and therefore the delivery date for the aircraft.

IV. AIRCRAFT MANUFACTURERS REQUIRE INCREASING AMOUNTS OF SPECTRUM TO CONDUCT FLIGHT TEST OPERATIONS SAFELY AND TO COMPLY WITH REGULATORY REQUIREMENTS

The Commission has recognized that "aeronautical telemetry bandwidth requirements have significantly increased in recent years as aircraft manufacturers collect increasing amounts of data and video concerning the performance of prototype aircraft."[20] This increase in bandwidth use by aerospace manufacturers in recent decades is due to increased system complexity, greater use of high definition video, larger testing footprints, and shorter aircraft development cycles.

Modern aircraft are increasingly using complex technology, which requires more testing, and therefore, increased demand for spectrum. The flight testing required in 1995 to complete the FAA certification process for Boeing's 777 aircraft included the electronic monitoring of approximately 64,000 individual data channels. The flight

[20] *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, Including Third Generation Wireless Systems*, ET Docket No. 00-258; *Amendments to Parts 1, 2, 27 and 90 of the Commission's Rules to License Services in the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands*, WT Docket No. 02-8, Fourth Notice of Proposed Rulemaking, 18 FCC Rcd 13235, 13260, ¶ 52 (2003).

testing required to certify Boeing's new 787 aircraft is expected to include the electronic monitoring of well over 125,000 (and continually increasing) individual data channels. In contrast, the certification process required in 1954 for Boeing's 707 aircraft included the monitoring of only about 300 data channels.

Not only has the total number of measurements vastly increased, but these measurements must also be undertaken with much greater frequency and precision. Boeing currently requires up to 400 test samples per second for each electronic monitoring device. As a consequence, the sample rates required by each individual sensor have increased several fold, often requiring digital outputs of 12, 16 and sometimes 32 bits per sample.[21]

The individual test aircraft's onboard instrumentation requirements greatly exceed the amount of available bandwidth for AMT. Test aircraft are now collecting data in Gigabits per second, but can only transmit 5-15 Mbits per second of data through AMT due to bandwidth limitations. Therefore, Boeing is forced to transmit only the most critical aircraft safety data being collected, typically 5-15 Mbits per second of the 400-plus Mbits per second of data being recorded onboard the aircraft. This problem is exacerbated in military and small commercial aircraft that do not have the space onboard to store the data that cannot be transmitted.

High definition video is likely to be used in the coming years to monitor airframe components, cockpit instrumentation, and personnel condition and actions.[22] This will

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[21] *See Spectrum Requirement for Aeronautical Mobile Telemetry*, United States of America, Document 8B/143-E at 2 (31 March 2005) ("Document 8B/143-E").

[22] *See* Darrell Ernst, Carolyn Kahn, and David Portigal, "The Economic Importance of Adequate Aeronautical Telemetry Spectrum," The MITRE Corporation, MTR 060202, 4-1, February 2007.

cause an order-of-magnitude increase in data capacity demand in the next ten years.[23] In addition, aircraft testing footprints are increasing in size due to the higher altitudes and faster speeds of new aircraft, which requires testing at greater distances.[24] Increased footprints reduce the ability to geographically reuse spectrum (a spectrum efficiency technique), which requires more spectrum as well as lower take off elevations for the ground station antenna to track the test aircraft.[25] Finally, global market forces demand reduced development, production, and testing cycles to speed the time it takes to bring new aircraft to market.[26] One way to reduce the airplane development cycle is to do more real-time testing, for which AMT is essential.[27]

These trends in the aerospace manufacturing and testing industry have driven exponential growth in the demand for spectrum and have resulted in heavy use of the 2360-2390 MHz band. The growing congestion of AMT operations in the band should not be exacerbated by the introduction of a spectrum use that would result in harmful interference and necessitate repetition of complex and costly flight tests using limited AMT spectrum resources.

[23] *Id*.

[24] *Id*. at 4-1 – 4-2.

[25] *Id*. at 4-2.

[26] *Id*.

[27] *Id*.

V. BOEING'S FLIGHT TESTS ARE MANDATED BY THE RULES OF THE FAA AND INTERNATIONAL AUTHORITIES, AND THE REQUIREMENTS OF THE DEPARTMENT OF DEFENSE AND OTHER GOVERNMENT AND COMMERCIAL CUSTOMERS

Flight test spectrum is used to ensure the safety and reliability of new and current aircraft. Boeing conducts critical testing necessary to validate new and derivative aircraft to meet certification requirements of the FAA and international and foreign aeronautical regulatory agencies, as well as to comply with the requirements of U.S. government customers. Boeing conducts flight testing in urban and rural areas throughout the United States.

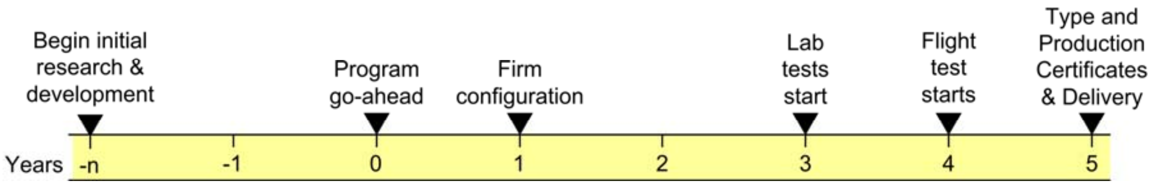
Flight testing is coordinated by BCA for commercial airplanes and by IDS for military aircraft, missiles and weapon systems. BCA conducts flight testing on each and every aircraft model and its derivatives. Extensive flight testing has been done on all commercial aircraft manufactured by Boeing, including the 737, 747, 747 Large Cargo Freighter, 767, and 777, and flight testing continues to be conducted on derivative versions of most of these aircraft. The 787 Dreamliner and 747-8 Freighter are also currently being prepared for flight testing. The 787 Dreamliner flight testing is planned to be conducted in Washington, Oregon, Idaho, Montana, California, New Mexico, Arizona and possibly other states depending on conditions.

IDS has conducted and continues to conduct flight tests on an even larger suite of aircraft, including the F-15, F/A-18 Hornet, and F-22 fighter/attack aircraft; C-17 Globemaster airlifter; 767 International Tanker; V-22 Osprey tiltrotor; AH-64 Apache helicopter; CH-47 Chinook heavy-lift transport helicopter; A/MH-6 Mission Enhanced Little Bird light helicopter; A-160 Hummingbird and other Unmanned Aerial Vehicles (UAVs); 737 Airborne Early Warning and Control; 707 Airborne Warning & Control

System (AWACS); US Navy E-6 TACAMO (Take Charge and Move Out) that supports the U.S. Navy's ballistic missile submarine force; Advanced Blended Wing Body aircraft; and other proprietary programs. IDS is currently conducting flight testing on the P-8A Poseidon, a long-range anti-submarine warfare, anti-surface warfare, intelligence, surveillance and reconnaissance aircraft. IDS also conducts flight tests for weapons platforms, such as the Joint Direct Attack Munition guidance systems, Small Diameter Bomb, Harpoon anti-ship missile, Conventional Air-Launched Cruise Missile, Counter Mine System warhead, Patriot Advanced Capability-3 and Standoff Land Attack Missile. Flight testing of these systems is conducted throughout the United States under government contract and frequency authorization, and not under grants of Commission authority.

Flight testing of commercial and military aircraft requires detailed planning, strict deadlines, efficiency, geographic flexibility and, most importantly, timely access to adequate spectrum in order to monitor real-time telemetry data to protect the safety of the flight crew.

An aircraft design and manufacturing program is typically a multi-year process. The first three or more years are typically devoted to configuration development and detailed design. Then another year is devoted to extensive laboratory testing, and another year is allocated to extensive flight testing. The first few months of a flight test certification program are devoted to flutter clearance and initial airworthiness testing to ensure that the basic design of the aircraft is safe. A typical program development timeline is shown below.



Flight Testing Program Development Timeline (in Years)

Initial airworthiness flight tests are by far the most hazardous to the safety of the flight crew and aircraft. Once Boeing has proven that the aircraft is airworthy, the FAA issues a Type Inspection Authorization certificate that states that FAA personnel are now able to fly onboard in order to validate that the aircraft meets the requirements outlined in the Federal Aviation Regulations ("FAR"). Complying with these requirements is necessary to obtain a Type Certificate.

A Type Certificate is awarded by aviation regulating bodies to aerospace manufacturers after it has been established that the particular design of a civil aircraft has fulfilled the regulating bodies' current prevailing airworthiness requirements for the safe conduct of flights under all normally conceivable conditions. At the completion of the flight test program, when the FAA has been satisfied that the aircraft meets all of the requirements outlined in FAR Part 25, the FAA issues Boeing a Type Certificate. Only after Boeing has received the Type Certificate will Boeing be able to begin delivery of a new aircraft or a derivative to its customers and begin to recoup its investment in development and testing.

Flight tests are conducted to obtain data that cannot be obtained either by computer analysis or lab test results and are the final determination that the aircraft design meets its intended function. Some of the tests for commercial aircraft include flutter tests,[28] initial airworthiness,[29] stall speed and stall characteristics determination,[30] wind-up-turns,[31] flight loads surveys,[32] cross wind landings,[33] refused takeoffs,[34] autopilot hard-overs,[35] abuse takeoffs,[36] engine starting following in-flight shutdowns,[37]

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[28] A series of in-flight conditions during which control surfaces are typically used to excite the structural modes of the airplane to demonstrate that the airplane is free from flutter and excess buffet throughout its design operating range. This range includes the flight envelope (altitude and airspeed), payload, fuel loading and control system configuration.

[29] The purpose of this test is to determine if the airplane is airworthy, conduct an initial investigation into the primary flight control laws, handling characteristics, and generally establish any areas of opportunity for further investigation. Test conditions include takeoffs, gear/flap/speedbrake extensions and retractions, turns, rolling and sideslip maneuvers, control surface "kicks," pushovers, pull-ups, stalls, wind-up-turns, rapid descents and landings. The term "airworthy" basically requires that the aircraft conforms to its Type Certificate and that it be in condition for safe operation. *See* 49 U.S.C. § 44704(c) and 14 C.F.R. § 21.183(a), (b), (c).

[30] Stall speeds and stall characteristics must be determined by flight testing for every combination of flaps and gear position that will be used in flight at zero thrust over the applicable gross weight range.

[31] A turning flight maneuver of slowly and continuously increasing bank angle and load factor at constant airspeed to obtain stick force per 'g' and elevator per 'g' characteristics in maneuvering flight.

[32] The purpose of a flight load survey is to measure loads on an airplane's primary structural components such as in the wing, fuselage, and empennage. Some of the test conditions include stalls, wind-up-turns, pushovers, pull-ups, rapid rolls, and sideslip maneuvers.

[33] For this test, landings are conducted with a cross wind (90-degree cross component) of 25 knots to demonstrate adequate lateral and directional control of the airplane.

[34] This testing is conducted to determine the refused takeoff braking performance and to develop the airplane brake force tables for Airplane Flight Manual (AFM) performance calculations. This testing also demonstrates maximum airplane brake energy and fuse plug energy capability.

[35] Autopilot hardover testing is performed to evaluate and demonstrate airplane response to and recovery from simulated single channel autopilot failures. The hardover failure (full authority autopilot actuator displacement) is typically the most severe of the single channel failures.

ground minimum control speed testing,[38] air/approach minimum control speed testing[39] and flight controls demonstration.[40]

Additional flight tests conducted by IDS for government and military aircraft include tethered hover performance,[41] forward flight performance,[42] handling qualities,[43]

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[36] After the normal takeoff performance is established, the FAA requires additional tests to prove that the scheduled takeoff distances and handling characteristics are satisfactory when the normal takeoff speed schedule and procedures are not followed. Testing consists of engine-out abuse takeoffs conducted at each takeoff flap setting at the minimum thrust per gross weight ratio. In addition, all-engine abuse takeoffs are conducted at the minimum thrust per gross weight ratio, at a higher than normal rotation rate, with a two-degree over-rotation and with the maximum mistrim that would not result in a takeoff configuration warning.

[37] The purpose of the engine starting testing is to determine the altitude, airspeed, and starting procedure necessary to restart the aircraft engines following an in-flight shutdown. Testing is conducted to demonstrate that an alternate electrical power source independent of the engine generators is available for restarting. Testing is also conducted to show that engine windmilling revolutions per minute (RPM) will drive the engine generators.

[38] Ground minimum control speed testing is conducted to determine the minimum speed during the takeoff roll at which, when the critical engine fails, it is possible to recover control of the airplane with the use of primary flight controls (rudder) only and safely continue the takeoff.

[39] The purpose of this testing is to determine the minimum airspeed at which, when the critical engine is made inoperative, it is possible to recover the airplane and maintain straight flight with the most unfavorable flap setting and takeoff thrust on the operating engine.

[40] The purpose of this testing is to demonstrate that new or modified primary flight control functions function as intended and are safe for continued flight operations.

[41] Testing performed with the aircraft linked to the ground by steel cables in greater than three knot wind conditions to determine the available power capacity of the aircraft.

[42] Testing the aircraft in level flight, and climbs and descents to the maximum capability of the aircraft. This data is used to develop performance charts for the aircraft operator's manual.

[43] Testing performed to determine if the static and dynamic handling qualities meet specification requirements and pilot expectations.

envelope expansion,[44] high angle-of-attack (HiAoA) / spin testing,[45] safe separation tests,[46] target acquisition system performance,[47] pilotage system performance,[48] weapons system accuracy,[49] aircraft survivability equipment function,[50] autonomous system performance,[51] communications range testing,[52] and navigation system performance.[53]

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[44] Testing to establish the envelopes for aircraft structural, performance and handling qualities. These envelopes may include day and night operations, weapons separation, accuracy testing and emergency procedure capabilities.

[45] Testing to examine the left side of aircraft flight envelope, including controlled flight, out-of-control flight, and recovery to controlled flight. Test methods include safe build ups in angle-of-attack with controllability checks, departures from controlled flight, steady state post departure conditions (spins, deep stalls, falling leaf, etc.) and recovery to controlled flight. Aspects that affect departure susceptibility (external weapons load-out, asymmetric load-out and operationally representative maneuvering) are also explored. This testing is considered higher risk and requires extensive test aircraft modifications and ground test prior to flight test.

[46] Testing performed to establish a safe separation envelope and to determine if the release of external stores, including weapons launches, can be safely accomplished within that envelope.

[47] Testing performed to determine if the integration of the target acquisition system to the aircraft meets specification requirements.

[48] Testing performed to determine if the integration of the pilotage system to the aircraft meets specification requirements and allows the pilot to operate the aircraft safely within its operating envelope while flying by referencing the pilotage system.

[49] Testing performed to determine if the end-to-end performance of the target acquisition system, navigation system and weapons system meets specification requirements.

[50] Testing performed to determine if various warning systems, jamming systems and threat defeating systems meet specification requirements.

[51] Testing performed with manned and unmanned platforms to verify automated control tasks such as takeoff, landing, cruise flight and mission execution.

[52] Testing performed to demonstrate that the communications systems meet the range performance requirements throughout the various frequency bands.

[53] Testing performed to acquire data used to determine navigation system accuracy. This data is used to determine the effects on the navigation system, flight control system, target acquisition system and weapons system performance.

In order to collect the data required to substantiate the test requirements, it is necessary for Boeing to equip its test airplanes with various transducers such as accelerometers (acceleration), strain gauges (load), pressure gauges (airspeed, loads, fuel flow), thermocouples (temperature), transducers (control surface and stick displacements), voltage and potentiometers (displacement) and cameras (motion analysis). The data produced by these devices, along with the information transmitted back and forth between the various avionics black boxes on the airplane, is either transmitted to the ground or, if possible, recorded on the test aircraft. In some cases, however, there is insufficient space on military aircraft and weapons systems to accommodate such recording devices. In any event, much of the data is needed for real-time analysis and is transmitted via telemetry data link to the telemetry room for real-time monitoring and assessment. These critical operations cannot be compromised by harmful interference from MBAN devices. As explained in the following sections, however, harmful interference is certain to result if MBANs are introduced into the 2360-2390 MHz band.

VI. MBANS WOULD CAUSE HARMFUL INTERFERENCE TO FLIGHT TEST OPERATIONS IN THE 2360-2390 MHz BAND AND THE PROPOSED PROTECTION MEASURES WOULD NOT BE EFFECTIVE AT PREVENTING INTERFERENCE

Boeing's AMT receive antennas are designed to be very sensitive to signals at distances up to 200 miles. Widespread deployment of secondary MBANs devices in the 2360-2400 MHz band would therefore cause harmful interference to primary AMT operations in the band.

GE Healthcare ("GEHC") proposes the widespread operation of wireless networks for multiple low-cost body sensors to monitor, diagnose and treat patients.

GEHC proposes to operate these MBANs on a secondary basis in the 2360-2400 MHz band primarily in hospitals and health care facilities, but also in ambulances.[54] These devices would wirelessly transmit data to a hub device either worn by the patient or located nearby. GEHC states that the devices would be used primarily for medical telemetry, i.e., measurement and recording, but could also be used to diagnose and treat patients.[55]

Under GEHC's proposal, MBANs would be limited to a maximum of 1 mW EIRP measured in the maximum emission bandwidth of 1 MHz.[56] GEHC proposes that MBANs be subject to the same out of band emissions limits as apply to the Medical Implant Communication Service (i.e., more than 500 kHz outside the authorized bandwidth).[57] Operating at these levels, GEHC recognizes that MBANs would cause interference to, and could not operate in range of, AMT antennas.[58]

As noted above, Boeing's 1.8 meter AMT receive antennas have a gain of 29.1 dBi and its 4.3 meter antennas have a gain of 38 dBi. AMT antennas track the aircraft being tested at very low elevation angles (often two degrees or less), and extremely low receive power levels due to the distance of the aircraft from the receive

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[54] *See* GEHC Ex Parte, ET Docket No. 08-59 at 6 (filed Mar. 4, 2009) ("GEHC March 4, 2009 Ex Parte").

[55] *See id*.

[56] *See* MBANs NPRM, 24 FCC Rcd at 9608, ¶ 65.

[57] *See id*. and GEHC March 4, 2009 Ex Parte at 6.

[58] This is presumably why GEHC proposes exclusion zones around AMT sites. *See* GEHC March 4, 2009 Ex Parte at 8.

antenna and the resultant path losses from the terrain and manmade structures.[59] Therefore, MBANs transmitting within radio line-of-sight of AMT receive antennas (particularly multiple MBAN devices) would interfere with the transmission of signals from the test aircraft to the AMT receive antennas.

The Commission appears to have recognized that MBANs would cause harmful interference to AMT receivers and has proposed several interference mitigation measures in an effort to protect AMT operations, including exclusion zones and a restriction on MBANs to indoor use. As explained below, these measures would ultimately not be effective at protecting AMT operations.

A. GEHC's Proposal for Use of a Contention-Based Protocol Would Not Protect AMT, and Could Make Interference Worse

The Commission confirms that a contention protocol would not protect AMT antennas against interference from MBANs.[60] When an aircraft is a significant distance from the AMT receive antenna, the use of contention based protocols would not prevent harmful interference to AMT operations from MBANs. An MBAN device would not detect the transmissions from an aircraft due to its distance from the device and therefore would not switch channels. The MBAN device would continue transmitting and cause interference to the AMT receive antenna, which would at best necessitate a full restart of the acquisition process, and possibly a re-test (and thus program delays). At worst, the interference could place the safety of the flight crew at risk.

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[59] The great distances at which the aircraft transmit and receive AMT communications results in weak signals.

[60] *See* MBANs NPRM, 24 FCC Rcd at 9608, ¶ 63.

In some test locations several aircraft are tested simultaneously. If one aircraft is close to an MBANs device, in which case the MBANs device may actually sense the communications from that aircraft ("Aircraft 1") to an AMT receive antenna on a channel ("Channel 1"), it would then switch to another channel ("Channel 2") that is being used by another aircraft ("Aircraft 2") and another receive antenna. If Aircraft 2 is far enough away, the low sensitivity MBAN device would not sense the AMT communications between Aircraft 2 and its receive antenna using Channel 2. The MBAN device would continue to transmit on Channel 2; the AMT receiver would pick up and track the closer MBAN signal, and drop the transmission from Aircraft 2. This loss of transmission lock could put the flight crew at risk or necessitate a full restart of the signal acquisition process for Aircraft 2.

B. Exclusion Zones Would Not Be Effective to Protect AMT Antennas Against Ubiquitous MBANs

In an effort to protect AMT operations, it has been proposed that the Commission establish exclusion zones around existing AMT test sites where MBANs would not be permitted to operate.[61] Specifically, the NPRM suggests that sharing between MBANs and AMT could be facilitated *if* the Commission establishes "*effective* exclusion zones around AMT flight test sites in the 2360-2395 MHz band to protect those sites from harmful interference."[62] As explained in the following sections, it is not possible for the Commission to establish *effective* exclusion zones due to the significant size of the

[61] *See* GEHC March 4, 2009 Ex Parte at 8.

[62] MBANs NPRM, 24 FCC Rcd at 9597, ¶ 22.

necessary exclusion zones, the need for flexibility in the locations used for AMT flight testing, and the unenforceability of exclusion zones on MBAN devices.

1. MBANs Exclusion Zones Must Be Large Enough to Protect AMT Receive Antennas Under a Worst-Case Analysis

The Commission acknowledges in its NPRM that "the use of exclusion zones could frustrate the widespread use of MBAN devices, particularly if it is determined in the course of this proceeding that such exclusion zones would be sufficiently large to encompass major metropolitan areas where MBAN operations might be prohibited."[63] In this regard, the Commission seeks comment on the size of the exclusion zones that would be necessary to protect AMT receivers.

In considering this issue, the Commission must examine worst-case conditions because the exclusion zones that are being proposed are intended to protect a recognized safety-of-life service. As the Commission has repeatedly recognized, interference to an AMT receiver can put the safety of the flight test crew at significant risk.

Boeing concurs with the analysis conducted by the Aerospace & Flight Test Radio Coordinating Council ("AFTRCC"), which has concluded that any exclusion zone must prohibit MBANs operation anywhere within line-of-sight of an AMT receiver. MBAN devices transmitting at 1 mW within line-of-sight of an AMT receive antenna would result in interference sufficiently significant to cause the AMT receiver to lose signal link with a test aircraft and begin tracking the MBANs signals. Further, the aggregate interference of multiple MBANs would increase the likelihood that harmful interference would disrupt and potentially imperil flight test operations.

[63] *Id*. at 9600, ¶ 36.

As a result, any exclusion zone that could be considered in this proceeding must reflect line-of-sight conditions. The adoption by the Commission of a substantial exclusion zone is not unprecedented. For example, the Commission established a 150 kilometer protection zone for wireless broadband service ("WBS") operations around FSS earth stations, employing a "high degree of worst-case conservatism."[64] In that case, the Commission employed "worst-case conservatism" even though it was not seeking to protect a safety-of-life service. In the instant case, the exclusion zones would be intended to protect a safety-of-life service. The Commission therefore must consider the worst case interference scenario, which necessitates the use of a substantial exclusion zone around AMT test sites in order to avoid risking the lives of flight test personnel.

2. Exclusion Zones, Regardless of Size, Cannot Protect Mobile AMT Receivers or Ensure Adequate Flexibility for Future AMT Requirements

Regardless of the size of the exclusion zones proposed, the Commission must also protect mobile and temporary AMT receivers and ensure that aircraft manufacturers have sufficient flexibility to accommodate the continued growth in flight test requirements. This necessity reveals a major flaw in GEHC's assertion that MBANs and AMT can coexist – GEHC assumes that AMT receive antennas exist only at fixed locations.[65]

As detailed above, efficient flight testing requires geographic flexibility to take advantage of favorable weather conditions and account for other flight testing variables,

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[64] *See Wireless Operations in the 3650-3700 MHz Band; Rules for Wireless Broadband Services in the 3650-3700 MHz Band*, ET Docket No. 04-151, WT Docket No. 05-96, Report and Order and Memorandum Opinion and Order, 20 FCC Rcd 6502, 6524 ¶ 60 (2005) ("WBS Order").

[65] *See* GEHC March 4, 2009 Ex Parte at 12.

such as runway length, geographic location, testing schedules and labor availability, often on short notice. Boeing must be free to use established AMT flight test ranges, new AMT flight test ranges, and temporary flight test ranges using its mobile telemetry units within a matter of days.

The new sites and temporary sites may not be collocated with established AMT sites subject to any proposed MBANs exclusion zones. For example, Othello, Washington – where Boeing is likely to conduct some of its 747-8 flight testing – is not a currently identified AMT flight test site and would not be protected by an exclusion zone under GEHC's proposal. Othello Community Hospital, located in northeast Othello, is licensed for 49 beds and serves a regional population of more than 10,000 people. If the Commission were to grant a secondary allocation to MBANs, multiple MBANs could be put into use at the Othello Community Hospital. If Boeing later commenced S-band AMT flight tests in Othello on short notice (as often happens), the secondary MBANs devices would be forced to shut down to avoid interference to Boeing's primary mobile AMT receive antenna. That outcome could cause serious safety risks to patients and subject the hospital to a risk of liability.

In this regard, the Commission has requested comment regarding whether new AMT sites should be protected by exclusion zones and how that could be accomplished if MBANs devices are already operating within the area.[66] Access to new and temporary mobile AMT sites on short notice is necessary for efficient and effective AMT flight testing and is becoming more essential. The timeframes for flight testing have become

[66] *See* MBANs NPRM, 24 FCC Rcd at 9605, ¶ 54.

shorter and more aircraft are being tested simultaneously, which increases demand for adequate flight test ranges.

As noted above, Boeing plans to simultaneously flight test the 787 Dreamliner, the 747-8 and the P-8A Poseidon beginning in the fourth quarter of this year. The demands of these simultaneous programs will require the use of both fixed and temporary AMT flight test facilities and locations.

Due to the importance of protecting AMT flight test operations, the proposed use of exclusion zones would not be effective because they would not be able to protect new or temporary AMT flight testing operations using mobile telemetry units, especially if MBAN devices already exist in an area. Alternatively, if the Commission were to approve the use of exclusion zones only for existing AMT sites and prohibit the short-notice use of new or temporary AMT sites, the utility of Boeing's mobile telemetry units would be compromised and the number of flight test location options greatly diminished. This could cause substantial delays in the flight test critical path and cost millions of dollars per aircraft in labor hours and delay penalties – costs that would eventually be borne by the public and the nation's economy.[67]

3. Exclusion Zones Would Be Ineffective Because They Would Be Unenforceable

With the likely ubiquitous use of MBANs devices, exclusion zones would also be ineffective because they would be unenforceable. GEHC claims that control of MBANs can be handled by hospital technical personnel to enable use of the 2360-2390 MHz band only outside of exclusion zones. Hospital personnel, technically-trained or otherwise, are

[67] *See supra* Section III. discussion of the costs of flight test delays.

not equipped to take responsibility for compliance with Commission regulations addressing spectrum use. Such medical staff generally lack the expertise and time to act as responsible licensees of MBANs, a fact that GEHC has recognized. In its arguments against a secondary allocation for WMTS in the 1427-1432 MHz band, GEHC agreed with the Land Mobile Communications Council that health care facilities generally do not "understand the differences between primary and secondary use" and that "health-care facility personnel would not understand that they have only secondary status on certain frequencies."[68]

GEHC also proposes using MBANs in ambulances. In fact, GEHC envisions thousands or potentially millions of these devices located in hospitals and in ambulances possibly under the control of hospital technical personnel that do not have a Commission license. Such deployments would result in the use of MBANs outside of hospitals and hospital technical personnel would likely have no knowledge of or control over where the MBANs travel or whether they enter an exclusion zone. They would also not have the ability to cease transmissions if the MBANs interfered with an AMT receiver.

Further, if a hospital knowingly or unknowingly released several patients wearing MBANs, the hospital technical personnel would have no way of knowing the patients' locations, and would be unable to keep them out of exclusion zones, or shut off the transmitters if they interfered with primary AMT transmissions. In this regard, it must be recognized that medical patients "check themselves out" of hospitals everyday without the immediate knowledge of hospital staff. Such patients may leave the hospital still wearing small MBANs devices. Although GEHC argues that the batteries in such

[68] Reply Comments of GE Healthcare, WP Docket No. 07-100 at 4-5 (filed Sept. 11, 2007).

devices would eventually drain, during the interim hours or days, uncontrolled MBAN devices would be moved around communities in an uncontrolled and unidentifiable manner, potentially resulting in harmful interference to AMT systems.

It is therefore not possible for the Commission to implement and enforce effective exclusion zones that would protect primary AMT flight test operations. Exclusion zones would not protect mobile and temporary AMT receivers. Exclusion zones also would not prevent patients from inadvertently carrying MBAN devices into exclusion areas. Finally, any exclusion zones that were adopted would have to be so large as to prohibit the use of MBAN devices in the 2360-2390 MHz band in numerous major metropolitan areas. The Commission should not employ such a cumbersome and unworkable approach in an effort to enable spectrum sharing between two recognized safety-of-life applications. Instead, the Commission should identify different spectrum that is truly available for the introduction of MBAN devices.

C. Mandating the Indoor Use of MBAN Devices Would be Insufficient to Protect AMT Operations From Harmful Interference

The Commission requested comment regarding whether "it would be appropriate to restrict the use of MBANs transmitting antennas to indoor locations" in the 2360-2390 MHz band.[69] If the Commission were to license MBANs in the 2360-2390 MHz band, they should be restricted to indoor locations. That restriction, however, would not prevent MBANs from causing harmful interference to primary AMT operations in the band. As demonstrated by AFTRCC in its comments, hospital buildings would not

[69] *See* MBANs NPRM, 24 FCC Rcd at 9609, ¶ 70.

always provide adequate attenuation. Further, any requirement for indoor operations would not be enforceable.

Although indoor use of MBANs would likely reduce interference to AMT receive sites when MBAN devices are transmitting in the interior of a building, the Commission must consider the worst-case scenario because of the safety implications of interference to AMT receive antennas and the real-time data necessary to keep flight crews safe during flight test maneuvers. The analysis for the worst-case scenario, as demonstrated by AFTRCC, must include multiple MBANs transmitting from upper level locations near the exterior of the building, such as those located in exterior rooms with windows.

Regardless of the anticipated attenuation provided by an indoor use restriction, the Commission cannot rely on the existence of such attenuation because an indoor use restriction would not be enforceable. As discussed previously, hospital staff would not be effective at enforcing an indoor use policy. Patients could leave hospitals and take MBANs with them that would continue to transmit interfering signals from any location potentially for days before the MBAN battery would die. Again, the hospital would have no way of tracking the patient's or the MBAN's movement after check out and no way to turn off the MBAN transmissions if harmful interference were to occur.

The Commission therefore cannot rely on an indoor use restriction to facilitate the introduction of MBAN devices in the 2360-2390 MHz band. Building attenuation would not always be adequate to protect AMT receivers. Further, any indoor use restriction would not be enforceable, resulting in multiple MBAN devices transmitting from unpredictable and uncontrollable locations.

VII. PRIMARY AMT OPERATIONS SHOULD NOT BE REQUIRED TO COORDINATE WITH SECONDARY MBANS

Apparently recognizing the large geographic areas in which MBANs would be prohibited if exclusion zones were adopted, the Commission has asked whether harmful interference to AMT flight testing could be avoided by requiring frequency coordination.[70] The Commission does not generally require that primary services coordinate with secondary services and should not in this case. To do so effectively strips the primary allocation of its regulatory status. The Commission has recognized that "[c]o-primary systems generally are obligated to coordinate with each other on a first-come, first-served basis, whereas a system operating under a secondary allocation must not give interference to, and must accept interference from, systems operating with primary status."[71]

In considering the possibility of requiring coordination, the NPRM discusses the coordination that was required between WMTS and non-medical telemetry in the 1427-1432 MHz band, and requests comment regarding whether the WMTS model would be feasible for MBANs and AMT operations.[72] In raising this possibility, the Commission acknowledges that the frequency coordination in the WMTS model "does not involve as many sites as could be required for MBAN and AMT coordination."[73] Beyond that

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[70] *See id*. at 9606, ¶ 56.

[71] *Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum and Adopt Service Rules and Procedures to Govern the Use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service*, IB Docket No. 07-101, Report and Order, FCC 09-64, ¶ 8, n14 (rel. July 31, 2009).

[72] *See* MBANs NPRM, 24 FCC Rcd at 9606, ¶ 58.

[73] *See id*. at 9600, ¶ 36.

important fact, several other reasons exist regarding why the WMTS model does not fit the proposed MBANs allocation.

In the WMTS Order, the Commission recognized the problems with the then existing secondary and unlicensed allocation for a safety-of-life service like WMTS and allocated 14 MHz of spectrum for its primary use. The Commission required that a frequency coordinator be assigned to maintain a database of WMTS equipment to facilitate the protection of government operations at protected sites.[74] This coordination involved co-primary operations (not primary and secondary) and the coordination process was required to protect "limited government operations at specific sites."[75] In contrast, any coordination with MBANs would require that the secondary devices be coordinated with at least 170 nationwide primary civil and government AMT flight test sites, plus additional mobile and temporary AMT facilities as the flight test obligations of aircraft manufacturers continue to increase.

The Commission later reallocated primary WMTS operations from the 1429-1432 MHz band to the 1427-1429.5 MHz band.[76] The Commission allocated the 1429.5-1432 MHz band on a primary basis to non-medical telemetry (primarily utility meter-reading).[77] The Commission provided for secondary operation by WMTS and non-medical telemetry on the other's primary spectrum and required coordination between the

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[74] WMTS Order, 15 FCC Rcd at 11217, ¶ 31.

[75] *See* MBANs NPRM, 24 FCC Rcd at 9606, ¶ 57.

[76] Reallocation of the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands, ET Docket No. 00-221, Report and Order and Memorandum Opinion and Order, 17 FCC Rcd 368, 392-393, ¶ 54 (2002).

[77] *Id*.

services.[78] The rationale for such primary/secondary coordination does not apply to primary AMT operations and secondary MBANs. First, WMTS operators have other primary spectrum that they can move to if coordination in the 1.4 GHz is unsuccessful. That would not be the case for MBANs. Second, non-medical telemetry, i.e., utility meter-reading, is not a safety-of-life service. As discussed in Section II. above, the Commission has recognized that AMT flight testing is a safety-of-life service.

The Commission also requests comment regarding whether the coordination applicable to WBS should apply to MBANs.[79] In the WBS Order, the Commission applied a worst-case scenario protection zone of 150 km around FSS earth stations.[80] The Commission, however, allows WBS operations within the protection zones if they negotiate agreements with the earth station operators. This coordination model is also inappropriate for MBANs. First, WBS is co-primary in the 3650-3700 MHz band, which facilitates coordination, unlike a primary and secondary relationship. Second, the number of FSS earth stations using the band is known and set. The FSS earth stations are grandfathered and Commission waiver is required to add any additional primary FSS earth stations.[81] Contrarily, because of the extensive government and military flight testing that is conducted using the S-band, the number and locations of AMT flight test sites will continue to change. Therefore, it would be inappropriate and ineffective to

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[78] 47 C.F.R. § 2.201, n. US 350.

[79] *See* MBANs NPRM, 24 FCC Rcd at 9606, ¶ 59.

[80] *See* WBS Order, 20 FCC Rcd at 6524, ¶ 60.

[81] *Id*. at 6505, ¶ 7, n.11.

require AMT operators to coordinate their primary use of the spectrum with secondary MBANs devices.

VIII. INDIVIDUAL LICENSING OF MBANS FACILITIES AND STRICT ELIGIBILITY DEMONSTRATIONS WOULD BE INADEQUATE TO PROTECT AMT OPERATIONS

The Commission has requested comment on the appropriate licensing approach for secondary MBANs in the 2360-2400 MHz band.[82] As a preliminary matter, the Commission seeks comment on a license-by-rule regime for MBAN devices. The Commission also seeks comment on individual licensing of MBANs facilities.

The Commission should refrain from adopting any allocation for MBANs in the 2360-2390 MHz band. If a spectrum allocation is adopted, each of the licensing options proposed by the Commission would be insufficient to protect critical AMT operations.

The Commission should not permit license-by-rule operation pursuant to Part 95 of the rules. Such a licensing regime would allow any MBANs device to operate within certain technical limitations without identifying a location or operator to the Commission. Therefore, MBANs operating inside exclusion zones or in areas where new AMT flight test sites are necessary could not be located and shut down. The Commission also would be unable to identify or contact medical facilities that were misapplying or disregarding the regulatory restrictions on the use of modular MBAN transmitters.

The Commission also suggests that the non-exclusive nationwide licensing approach applicable to WBS in the 3650-3700 MHz band might be appropriate for MBANs.[83] The licensing regime applicable to the co-primary WBS would not be

[82] *See* MBANs NPRM, 24 FCC Rcd at 9600-9601, ¶¶ 35-36.

[83] *See id*. at 9600-9601, ¶ 36.

adequate for secondary MBANs. The WBS regime involves licensing fixed and base stations on a primary basis that can be reliably restricted from being located within the protection zones around FSS earth stations.[84] The Commission recognized in the WBS proceeding, however, that mobile operations "pose a greater risk of causing interference" to the protected FSS earth stations.[85] The Commission therefore required that, before mobile WBS devices could transmit, they first had to positively receive and decode an enabling signal transmitted by a base station so that the mobile station "knows" it is within a reasonable distance of a base station and therefore far from an FSS earth station.[86]

MBANs are not fixed stations that can be licensed individually and restrict the operations of mobile MBAN devices. The MBAN devices are designed to be inexpensive and disposable, so they are unlikely to be designed with the kind of listen-before-talk ("LBT") capability required of mobile WBS stations. Further, MBAN devices are designed to be mobile (*i.e.*, carried on the patient's body or nearby) and therefore there is no way for the MBAN device to receive a locating signal from a base station the way the mobile WBS station does. In the WBS Order, the Commission recognized the interference concerns inherent in mobile transmitters, but was able to require the necessary LBT technology for mobile WBS stations. Similar precautions cannot be taken for MBANs.

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[84] *See* WBS Order, 20 FCC Rcd at 6520, 6524, ¶¶ 50, 60.

[85] *Id*. at 6520, ¶ 51.

[86] *See id*. at 6521, ¶ 51.

Further, the WBS rules contain only limited eligibility criteria (e.g., restriction on foreign ownership).[87] This is in part because WBS providers are primarily commercial communications network operators that have expertise in controlling radiocommunications services. In contrast, as GEHC acknowledges, hospital personnel do not have the expertise (or time) to manage and control MBAN technologies.

Because of this, the Commission would have to require as a part of any licensing regime for MBAN devices that individual applicants include strict eligibility demonstrations in their license applications. Hospital MBAN applicants would have to demonstrate expertise in the communications technologies involved in MBANs equipment, its technical relationship to other communications services in the 2360-2390 MHz band, and the specific requirements (and the implications of those requirements) of the Commission's rules. The hospital would also have to demonstrate that its employees that possess this communications regulatory and technical expertise have sufficient administrative authority within the hospital facility to ensure that doctors, nurses, administrators and technicians comply with the Commission's requirements for MBANs. In this regard, applicants would need to demonstrate how they would restrict MBANs to indoor use, restrict operation within exclusion zones and cease transmissions immediately upon notice of harmful interference to primary AMT operations.

In the event that the manufacturer or distributor of an MBANs device sought to secure a license from the Commission, additional showings would be needed as well. For example, any MBANs manufacturer/operator applicant would have to be required to demonstrate how it would exercise control over the MBANs located in a hospital or

[87] *See id*. at 6515, ¶ 38.

medical facility (e.g., would the manufacturer/operator have an employee located at the hospital that is responsible for restricting MBANs to indoor use, restricting operation within exclusion zones and ceasing transmissions immediately upon notice of harmful interference to primary AMT operations?). The MBANs manufacturer/operator would also have to demonstrate that it has sufficient authority within the hospital to comply with these requirements and to restrict the frequencies available for MBANs.

In raising these issues, Boeing recognizes that each and every individual MBANs device cannot be separately licensed by the Commission. At the same time, however, the Commission should recognize that issuing individual licenses to individual healthcare facilities or MBANs manufacturers would be inadequate to protect important AMT operations. Thousands of band-aid sized MBANs devices may be employed in some hospitals and hospital staff, regardless of their expertise, could not be effective in restricting the operations of the devices to solely within healthcare facilities. Patients would leave with MBANs devices on their person and some healthcare staff would not adequately understand the restrictions on their use in the band to adequately protect primary AMT operations.

The significant problems associated with identifying a viable licensing regime for the operation of MBAN devices in the 2360-2390 MHz band serves only to further demonstrate the significant shortcomings in GEHC's proposal – it is entirely inappropriate to allocate a safety-of-life medical service such as MBANs on a secondary basis in a spectrum band where the primary user is also a safety-of-life service that invariably would receive harmful interference from the secondary service. MBAN devices may be a desirable product to make available to patients and the medical community, but its proposed operations in the 2360-2390 MHz band is unworkable, unsafe, and inappropriate.

IX. CONCLUSION

Boeing fully supports the comments and analysis filed by AFTRCC and opposes GEHC's proposal to operate MBANs on a secondary basis in the 2360-2400 MHz band. AMT flight testing is a critical safety-of-life service that must remain flexible and mobile to be safe and effective. The Commission should reaffirm the important public interest and public safety benefits that are achieved by flight test operations. The Commission should also acknowledge that AMT operations cannot be protected adequately from harmful interference caused by MBANs using mitigation techniques such as unenforceable coordination or exclusion zones around a set number of existing AMT sites. Indoor use restrictions would also be ineffective. Therefore, the Commission should not permit MBAN devices to operate in the critically important 2360-2390 MHz band.

Respectfully submitted,

THE BOEING COMPANY

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October 5, 2009

EXHIBIT

Seattle S-band Noise Floor Measurements

The Boeing Company
Seattle, WA
September 18, 2009

Thomas F. Fisher
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BCA Flight Test

Table of Contents

Appendixes

1. Introduction

1.1 Summary

This report documents measurements made of the noise floor in the 2360-2400 MHz band (“S-band”) allocated for Aeronautical Mobile Telemetry (“AMT”) in the Seattle, Washington area. These measurements were taken using the actual equipment used for Boeing’s telemetry testing. The measurements shown here were taken between July and August, 2009.

1.2 Measurement Goals

The goal of this testing was to determine the current background S-band noise levels in the Seattle area at different times of the day across several days.

2. Noise Floor Measurement Equipment Description

2.1 Noise Floor Measuring Equipment

To measure the S-band noise floor, Boeing employed the existing telemetry antenna located at Boeing Field in Seattle, Washington. The antenna used was a Malibu HD40-1.8M dual band tracking antenna. This is connected to the telemetry room with an Andrews 2.25 inch heliax for Left Hand Circular Polarization (“LHCP”) and a 7/8 inch heliax for Right Hand Circular Polarization (“RHCP”). All measurements were made with an Anritsu MS2721B spectrum analyzer.

The Malibu dual band tracking antenna consists of a 1.8 meter reflector, a radscan feed, two PCS filters, and two Low Noise Amplifiers (LNAs). There is one filter and one LNA for each polarization. This antenna uses a hybrid to generate Right and Left hand circular polarizations from the received linear signals. A block diagram of this equipment is shown in Figure 1.

The HD40-1.8M antenna is installed on the roof of Boeing’s 3-801 building, located at 7755 East Marginal Way South, Seattle, Washington. It is connected to the test facility via two inter-facility link (“IFL”) cables approximately 120 feet long. Measurements were taken using a 10 dB coupler that was installed between the IFL cables and the Microdyne MRA-4000 telemetry receiver. This configuration is shown in Figure 2.

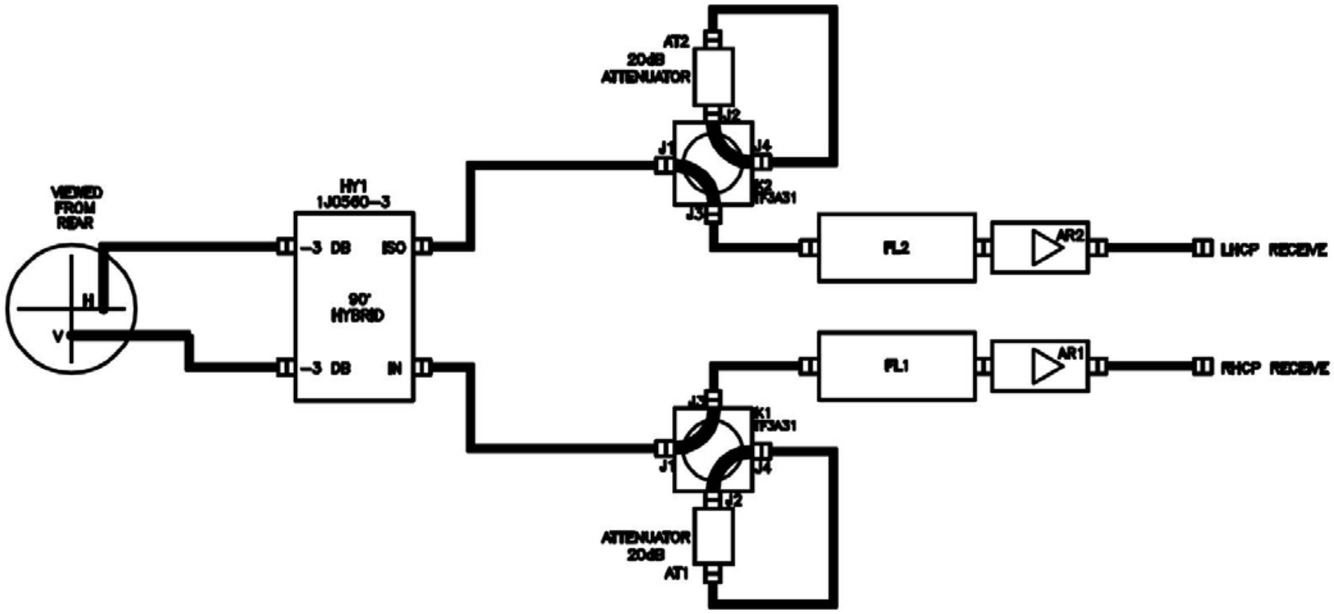


Figure 1: Configuration of HD40-1.8M Antenna (from the Malibu HD40-1.8M Operation and Maintenance Manual)

Detailed List of Antenna Components

- Reflector
  - Malibu 1.8 meter CFE solid parabolic antenna reflector, 29.1 dB gain and 4.6 degree beamwidth (3 dB) at 2400 MHz.
- 90 Degree Hybrid Coupler
  - 1420 - 2490 MHz, 28 dB isolation typ. (23 dB min), Amplitude balance +/- 0.5 dB, Phase balance +/- 2.0 degrees max
- Filter/Diplexor
  - Micro-tronics DIP14184, passband 1435-1540 MHz, 2200-2400 MHz, 0.6 dB insertion loss, 50 dBc out of band rejection
- Low Noise Amplifier
  - Miteq, AMF-3F-0143502485-04-10P-GW, 1435–2485 MHz, 35-40 dB gain, Gain Flatness 1.0 dB max, 0.4 dB Noise Figure (max)
- System Controller
  - Malibu Antenna Control Unit (ACU) model P500

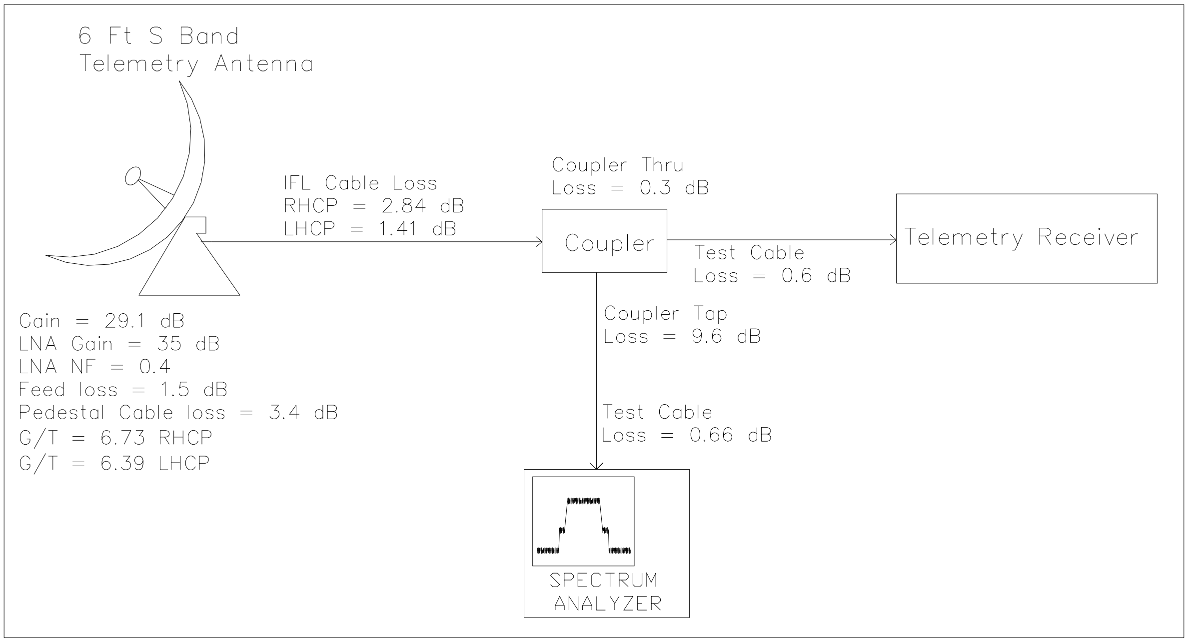


Figure 2: Drawing of HD40-1.8M installation and measurement setup

3. Gain Measurements

3.1 Gain Measurement Equipment

The figure of merit (G/T) of an antenna system is the ratio of antenna gain to the effective system noise temperature. The G/T of the Malibu antenna system was measured during factory acceptance testing using the sun calibration method. The value of G/T was calculated from the ratio of receive power of the sun versus pointing at a cold sky. Shown below are the averaged results of these measurements. S-band was measured at 2200 MHz. The elevation angle was approximately 56 degrees during the sun measurement.

Table 1: G/T Results of Malibu HD40-1.8M Antenna

Band/Polarization	G/T
L Band, RHCP	3.5 dB/K
L Band LHCP	3.33 dB/K
S Band RHCP	6.73 dB/K
S Band LHCP	6.39 dB/K

3.2 Gain Measurements for the Filter & LNA Assembly

Shown in Table 2 are the factory test measurements for the filters and LNAs.

Table 2: Filter & LNA Assembly Gain Measurement Results

Frequency	Gain/Loss
LNA #1@ 2280 MHz	+38.6 dB
@ 2390 MHz	+38.8 dB
@ 2500 MHz	+38.7 dB
LNA #2 @ 2280 MHz	+38.5 dB
@ 2390 MHz	+38.6 dB
@ 2500 MHz	+38.5 dB
Diplexor 1@ 2200 – 2400 MHz	-0.55 dB
Diplexor 2@ 2200 – 2400 MHz	-0.56 dB

During testing, the measured gain of the LNAs was closer to 35.0 dB rather than the 38 dB that was indicated on the manufacturer's data.

3.3 Attenuation Measurements for the Heliax IFL Cables

All cable losses were measured using the tracking generator in the Anritsu MS2721B. The losses of the cables used in this testing are shown in Table 3. All losses were measured at 2374.5 MHz, which is the center frequency for Boeing's telemetry testing. The 2.25 inch heliax is made by Andrews, model HJ12-50. It has a loss of 0.956 dB per 100 foot at 2300 MHz. The 7/8 inch heliax is also made by Andrews, model HJ5-50. It has a loss of 2.03 dB per 100 feet at 2300 MHz. The ends of the 2.25 inch heliax are connected by 7/8 inch cable in order to accommodate the sharp bends necessary to enter the equipment rack.

Table 3: Inter – Facility Link (IFL) Cable Losses

Frequency	Loss
RHCP Heliax @2374.5 MHz	- 2.84 dB
LHCP Heliax @2374.5 MHz	- 1.41 dB

The tracking generator was also used to measure the loss of the 10 dB coupler and the coaxial cable connected to the spectrum analyzer. The loss of the pedestal cables was also measured between the feed assembly and the base of the pedestal. The results are recorded in Table 4.

Table 4: Coupler and Coaxial Cable Losses

Frequency	Attenuation
Coupler @ 2374.5 MHz	-9.6 dB
Coaxial Cable @ 2374.5 MHz RHCP Pedestal Cables LHCP Pedestal Cables	-0.6 dB -3.4 dB -3.1 dB

4. Measurement Site

4.1 Location

The telemetry antenna used in these study measurements is located on the roof of the 3-801 building, located in the Boeing Plant 2 facilities at 7755 East Marginal Way South, Seattle, Washington. The antenna is approximately 90 feet AGL. The following pages include pictures taken from the site of the test antenna, which show the airport and industrial area around the site. Downtown Seattle is located approximately 5 miles to the north of the facility. The following Google Earth picture (Figure 3) provides an overhead view.

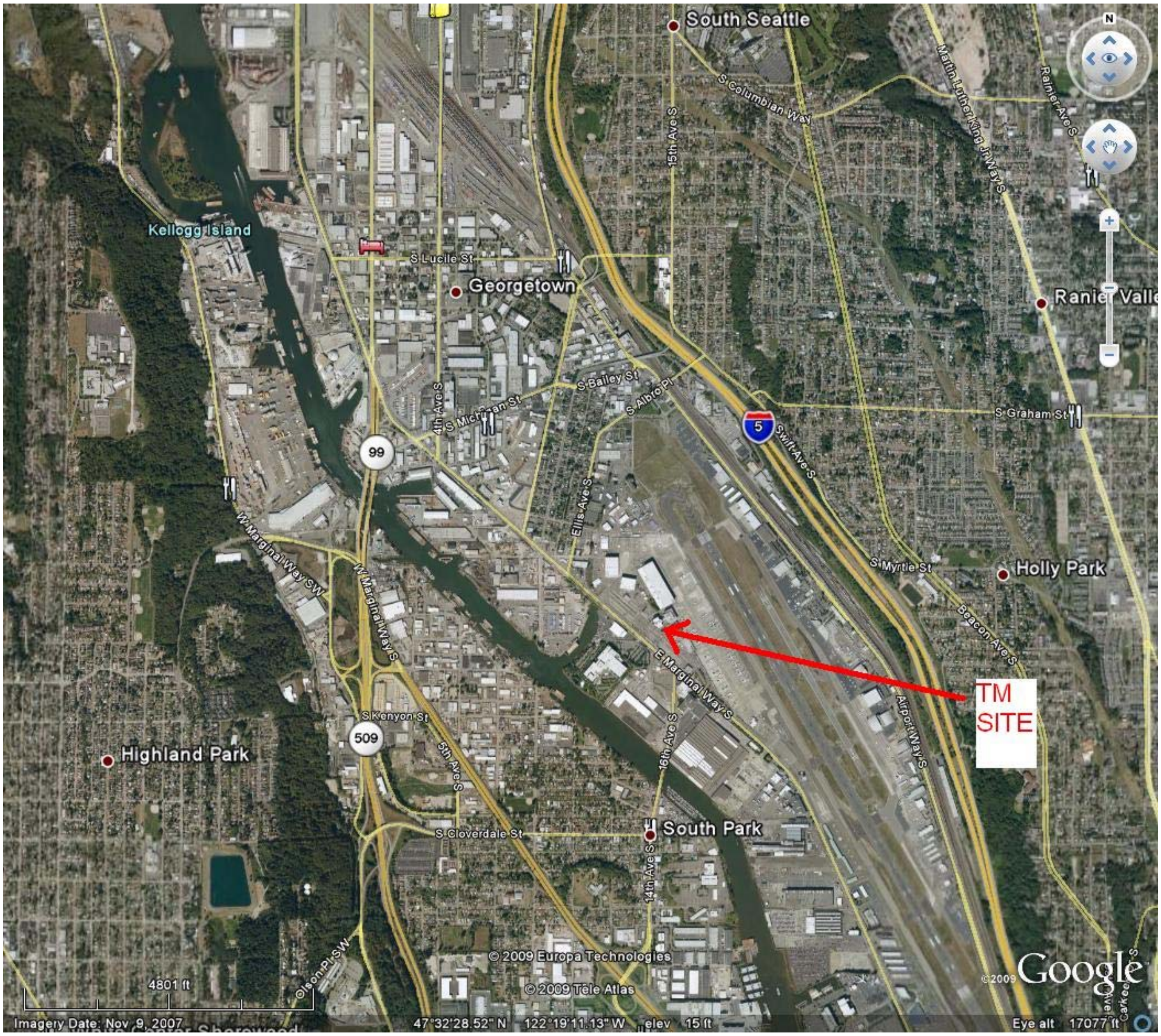


Figure 3: Overhead view of the Seattle test facility from Google Earth.

4.2 Views from Measurement Site

Figure 4: View to North showing downtown Seattle in the distance


Figure 5: View to South East showing Boeing Field

Figure 6: View to South showing the industrial nature of the area.

4.3 Spectrum Analyzer Noise Floor

Measurements were made to determine the noise floor of the Anritsu MS2721B spectrum analyzer. This was necessary to determine if the spectrum analyzer had the dynamic range necessary to measure the S-band's low signal levels. Figure 7 shows the noise floor of the spectrum analyzer terminated into 50 ohms with the pre-amp enabled. The level shown is approximately -167 dBm. The specification for this analyzer is a typical Displayed Average Noise Level (DANL) of -160 dBm. The equivalent noise figure of the spectrum analyzer in this frequency range is 18 dB.

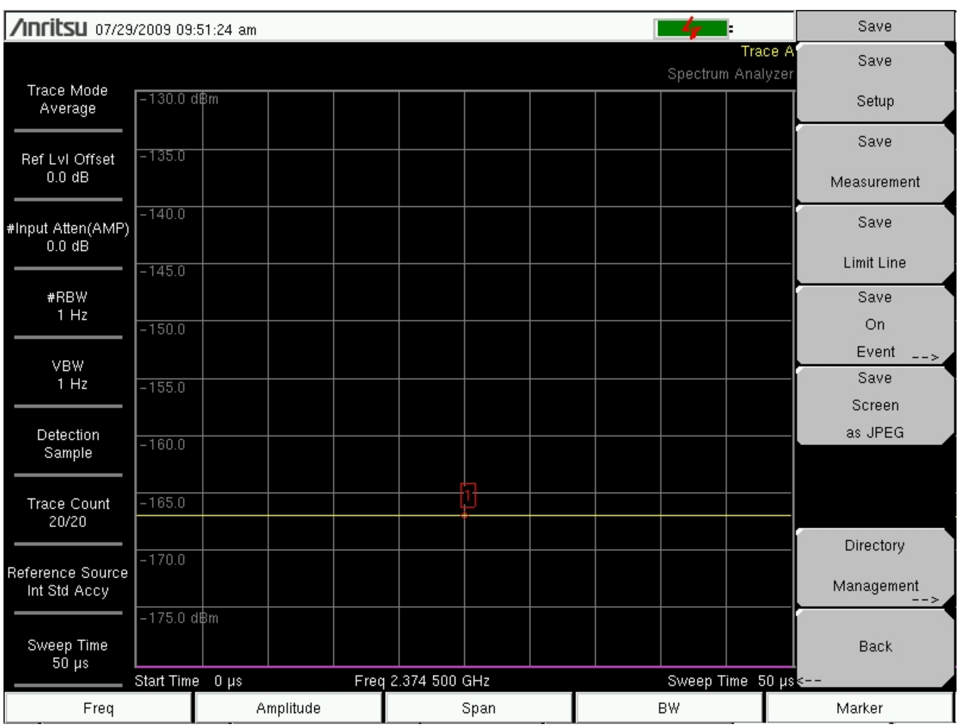


Figure 7: Spectrum Analyzer Noise Floor

Figure 8 shows the typical noise floor of our antenna system. This measurement was made at 0 degrees azimuth with the spectrum analyzer set to 0 span and the results were averaged over 20 samples. The averaged result was approximately -148 dBm.

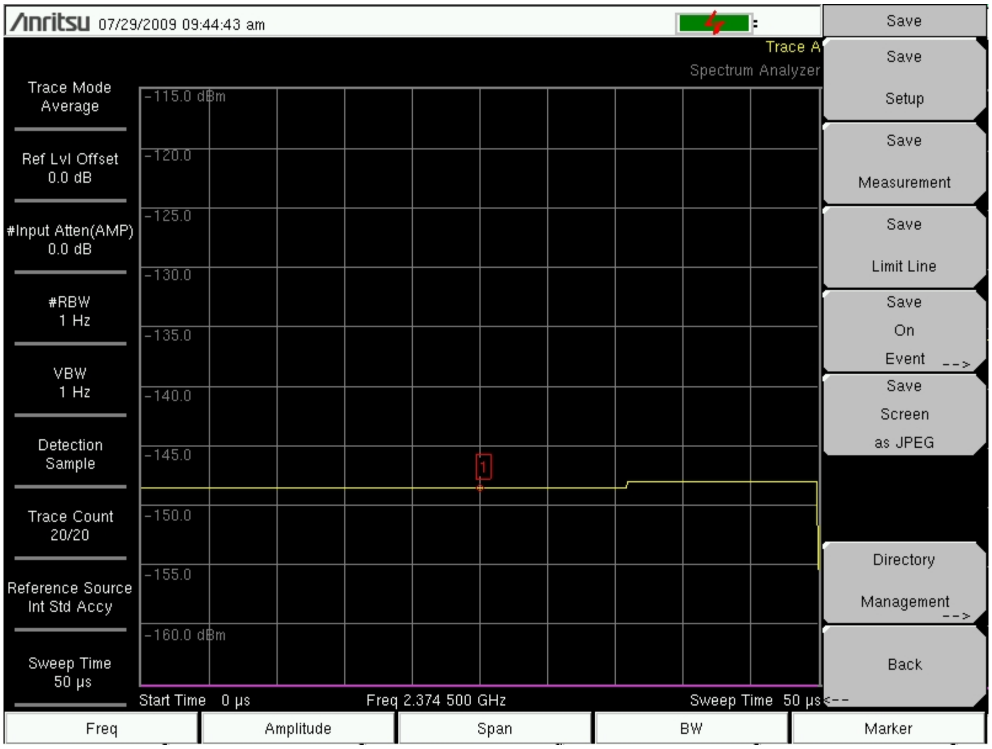


Figure 8: Noise floor of the HD40-1.8M Antenna System

4.4 Measurement Azimuths

The beamwidth of the antenna is +/- 4.6 degrees (3 db points), and each measurement takes three or more minutes. Because of this, it was decided to measure every 10 degrees of azimuth. Since most of Boeing's testing involves aircraft operating at distances up to 200 miles from the receive site, elevation angles rarely exceed 3 degrees. Thus, all measurements were made at an elevation angle of 0 degrees.

The relevant S-band spectrum includes 2360-2390 MHz. Thus, with a span of 20 MHz, two different measurement passes were required. The frequency of the first pass was set to 2370 MHz, the second pass was set to 2390 MHz.

5. Data Measured

5.1 Spectrum Analyzer Settings

Setting the spectrum analyzer to a very narrow resolution (1 Hz) led to very long measurement times (20 minutes or more per sweep). Since 72 measurements were required for each run, it was decided to increase the resolution slightly which significantly shortened the measurement times.

The spectrum analyzer was set up with resolution bandwidth of 30 Hz and a video bandwidth at 10 Hz. This resulted in a sweep time of 104.88 seconds which was a reasonable compromise.

5.2 Actual Data

Appendix 1 shows a listing of all measurements made using this S-band system. This section includes measurements from 0 to 350 degrees in azimuth for both right hand and left hand circular polarizations. The frequencies of 2370 and 2390 MHz were each measured with a span of 20 MHz. This resulted a continuous sample from 2360 to 2400 MHz. Shown in Figure 9 is a sample measurement.

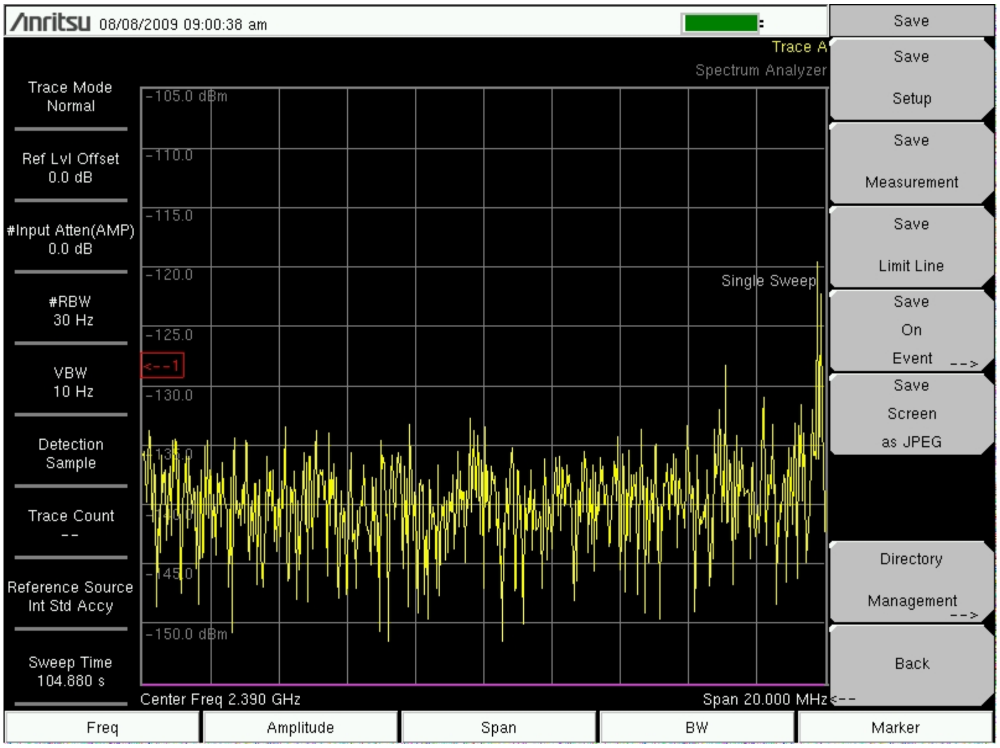
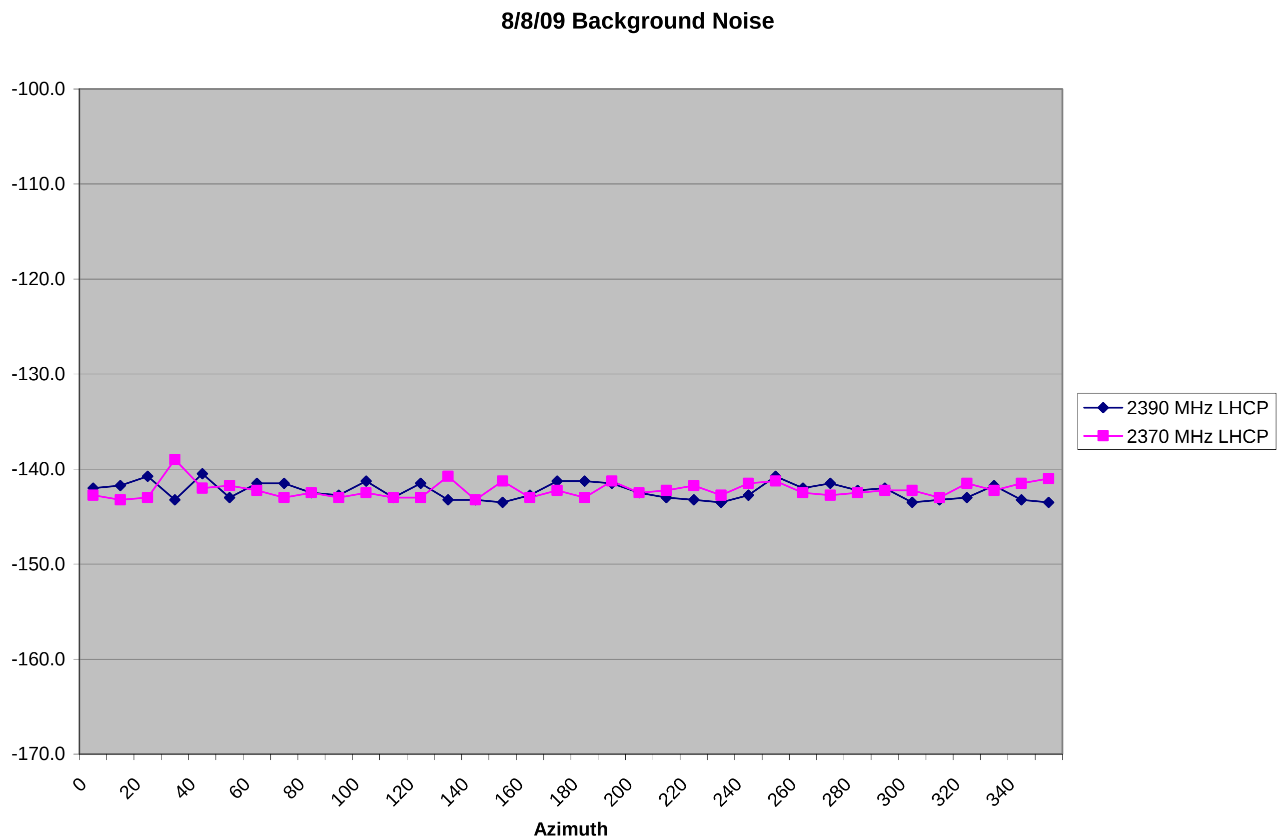


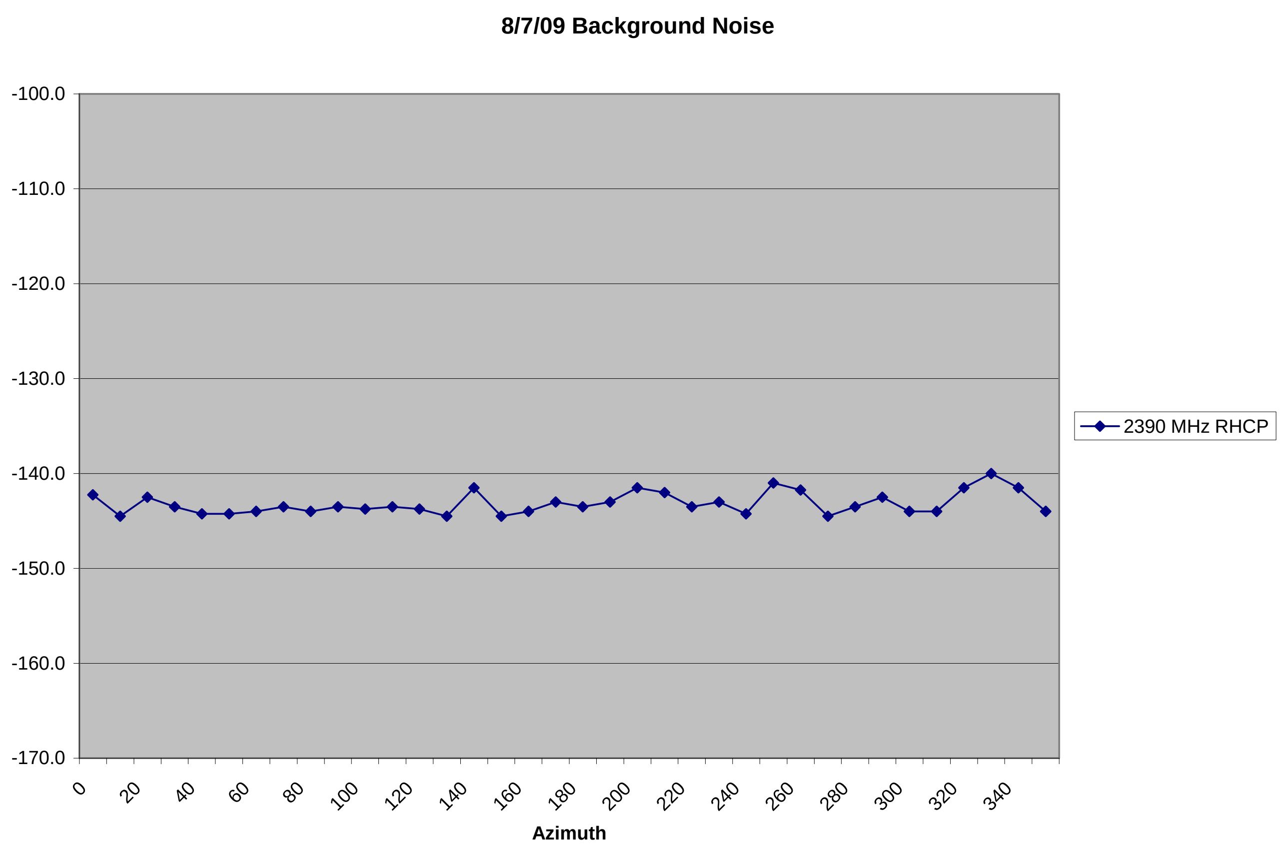
Figure 9: Sample picture of background measurement data

5.3 Spectrum Measurement Summary

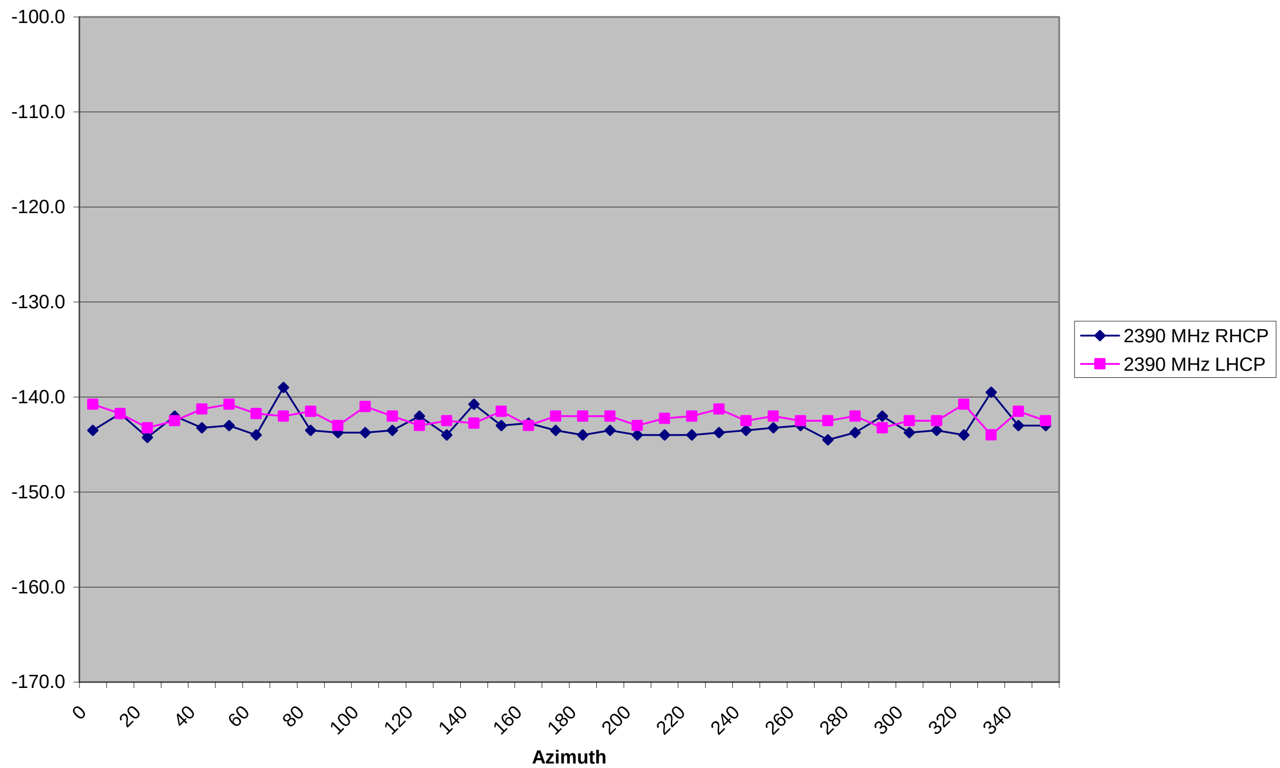
The following charts show a summary of the background noise that was measured. Due to time constraints, some measurements include RHCP data only, but in all cases LHCP data was very similar to RHCP data.

The last chart shows the measured noise floor at various times of the day. There is not enough data to draw firm conclusions but there is an indication that background noise increases during work hours. This is to be expected due to the industrial nature of the test location.

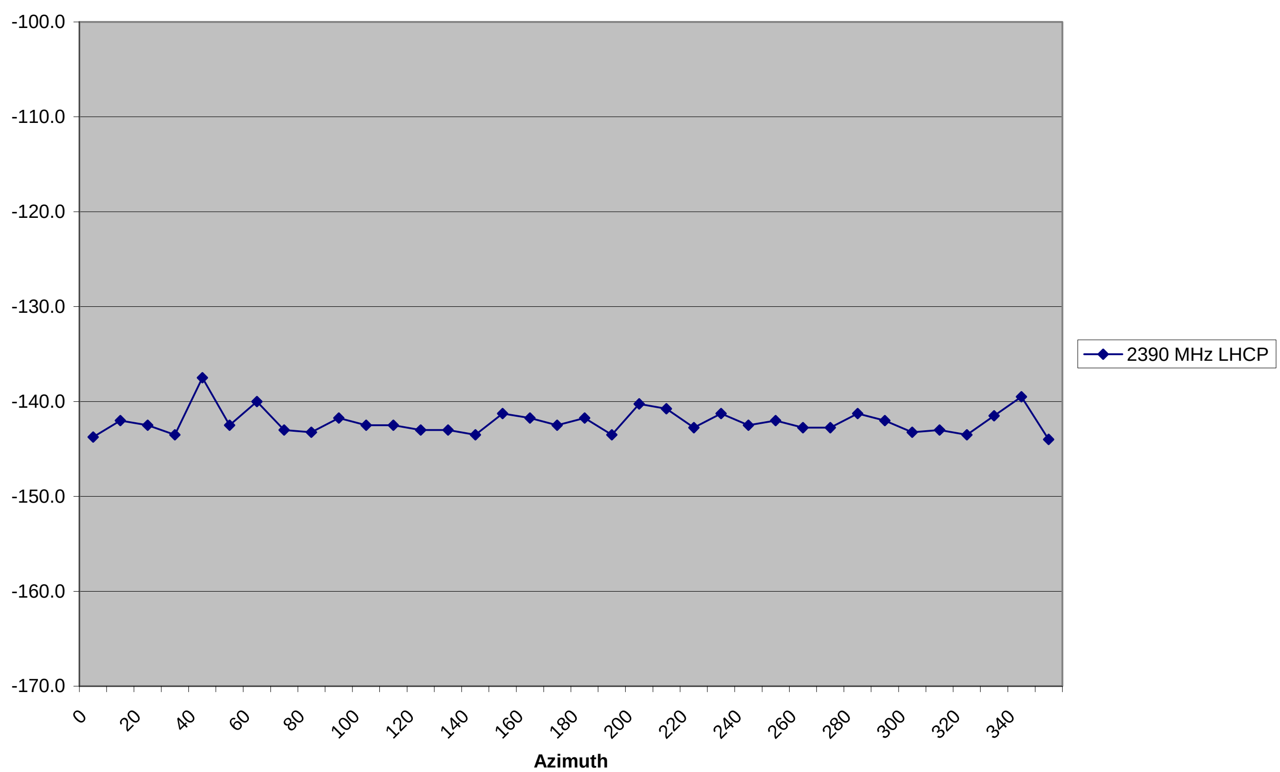

8/8/09 Background Noise
-100.0
-110.0
-120.0
-130.0
-140.0
-150.0
-160.0
-170.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Azimuth
2390 MHz LHCP
2370 MHz LHCP

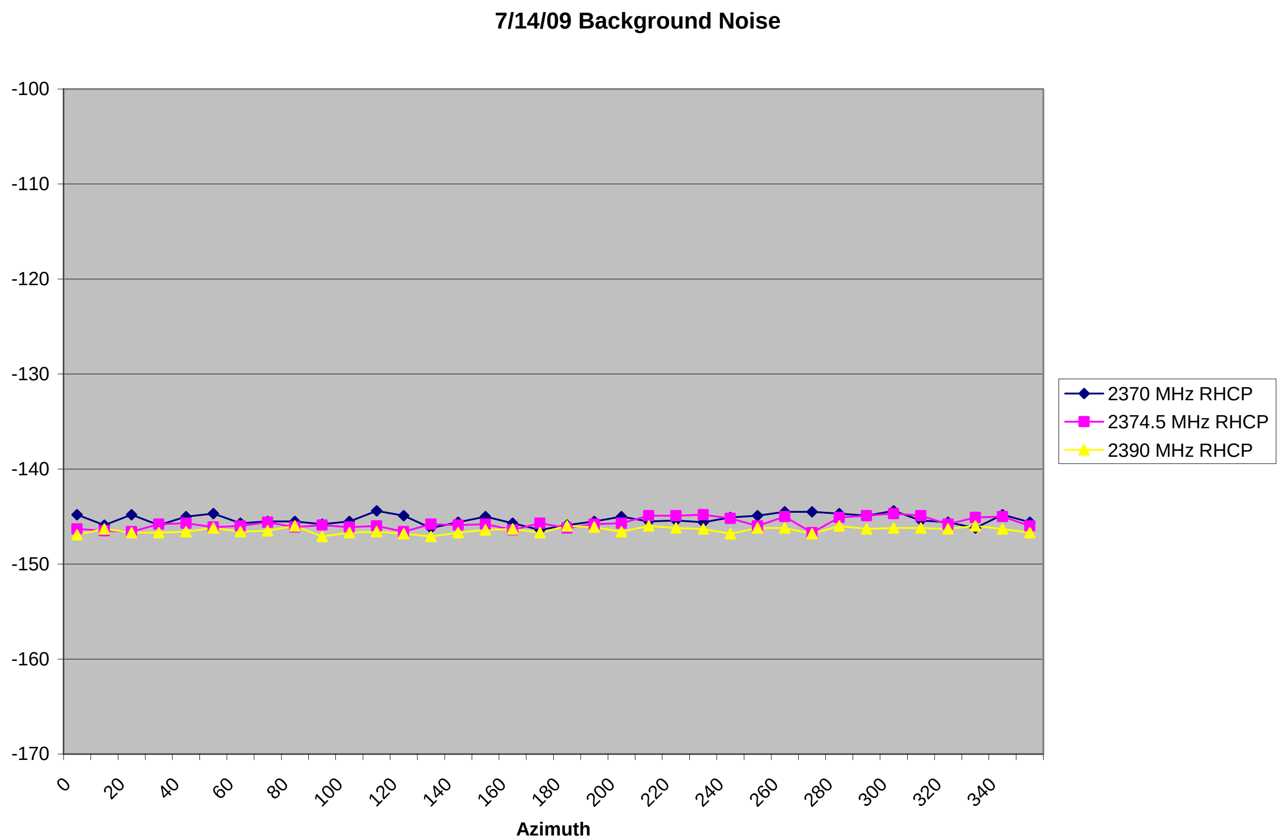

8/7/09 Background Noise
-100.0
-110.0
-120.0
-130.0
-140.0
-150.0
-160.0
-170.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Azimuth
2390 MHz RHCP

8/5/09 Background Noise



8/4/09 Background Noise

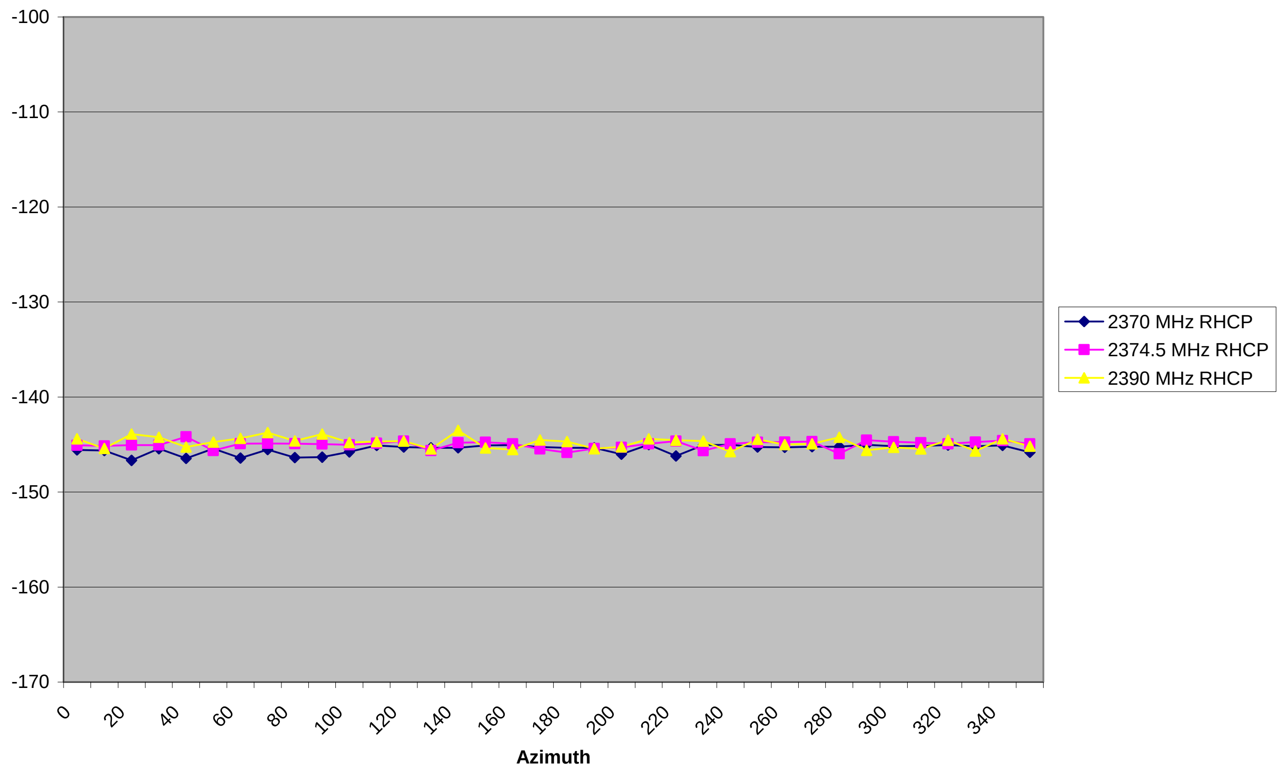




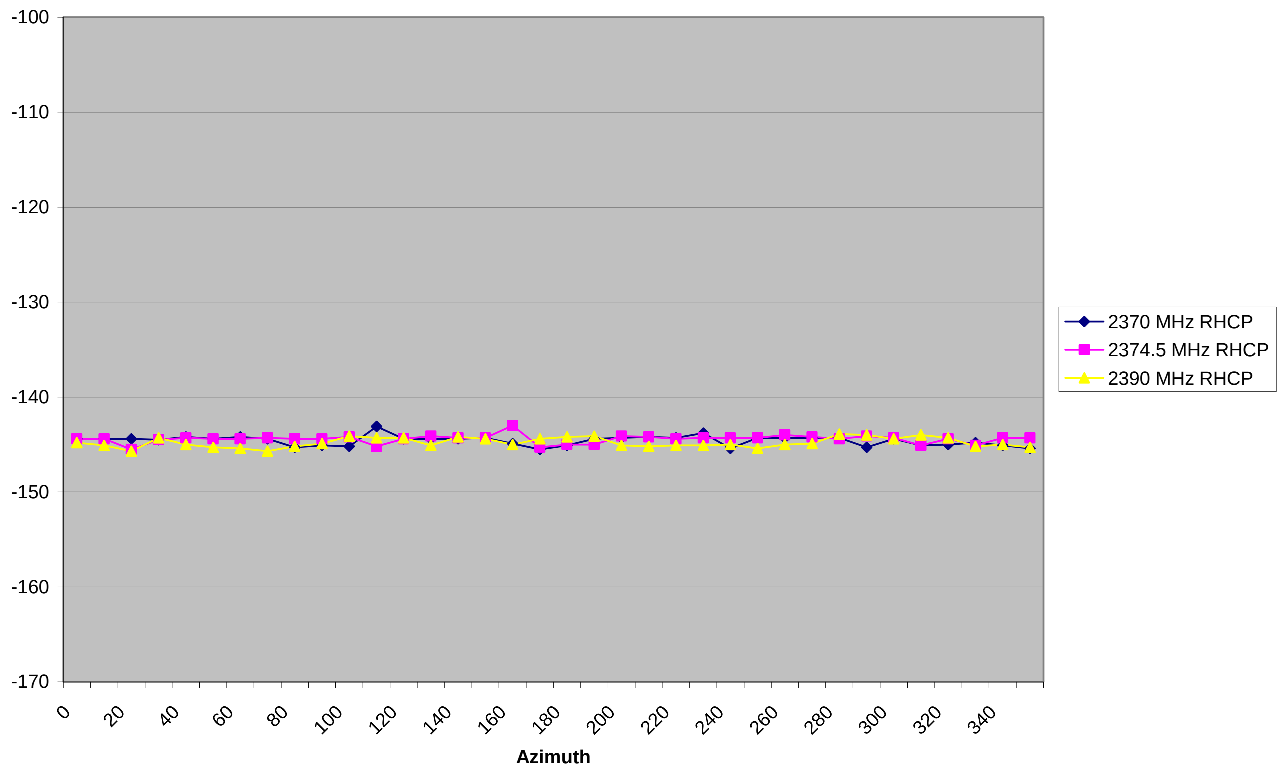
7/14/09 Background Noise
-100
-110
-120
-130
-140
-150
-160
-170
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Azimuth
2370 MHz RHCP
2374.5 MHz RHCP
2390 MHz RHCP

7/10/09 Background Noise
-100
-110
-120
-130
-140
-150
-160
-170
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Azimuth
2370 Mhz RHCP
2374.5 MHz RHCP
2390 MHz RHCP

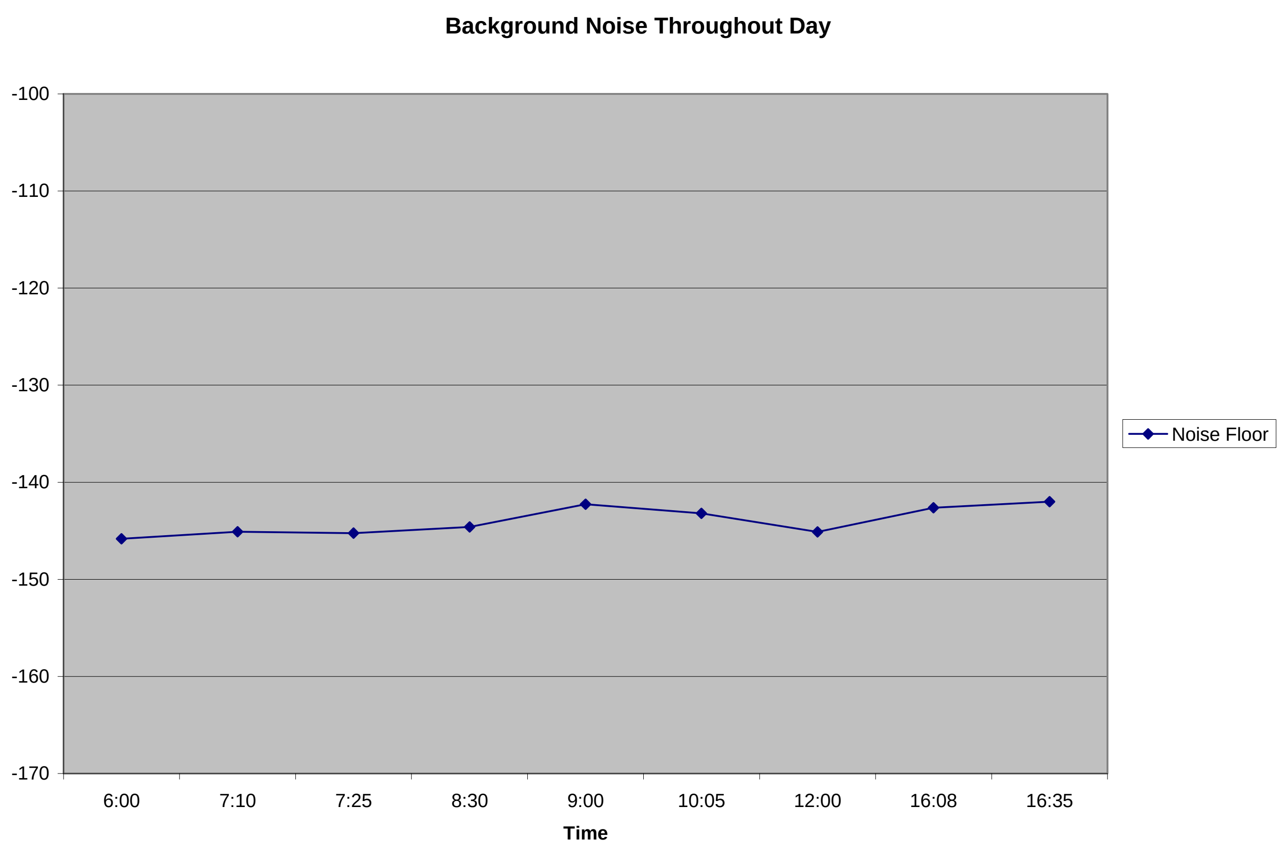
7/9/09 Background Noise



7/7/09 Background Noise



7/2/09 Background Noise
-100
-110
-120
-130
-140
-150
-160
-170
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Azimuth
2370 MHz RHCP
2374.5 MHz RHCP
2390 MHz RHCP



Background Noise Throughout Day
-100
-110
-120
-130
-140
-150
-160
-170
6:00
7:10
7:25
8:30
9:00
10:05
12:00
16:08
16:35
Time
Noise Floor

6. Calculations

The noise floor can be calculated using the following equations:

Noise Floor = k + 10 Log (T_{Ant} + T_{lna} + T_{Ped} + T_{IFL} + $T_{Coupler}$ + T_{Rx}) + 10 Log (BW)

<u>Where:</u>
k = Boltzman's constant (-198.6 dBW/K/Hz)
T_{Ant} = Antenna Noise Temperature = 210.9 degrees K
T_{lna} = Low Noise Amplifier (LNA) Noise Temperature
T_{Ped} = Pedestal cable loss Noise Temperature
T_{IFL} = Inter-Facility Link Cable Loss Noise Temperature
$T_{Coupler}$ = Coupler Noise Temperature
T_{Rx} = Receiver Noise Temperature
BW = Receiver Band Width (in Hz) = RBW of Spectrum Analyzer

<u>Substituting</u>

Noise Floor = (-198.6 dBW/K/Hz)+210.9 K+27.98 K+0.11 K+0.19 K+3.71 K+254.37+10 Log (30 Hz)

Noise Floor = - 156.86 dBm

The measured noise floor was -148 dBm which, while low, does reflect the industrialized nature of the test area.

7. Conclusion

The average noise level for our Seattle S band telemetry system is approximately -142 to -148 dBm depending on the time of day measured. Spillover interference from signals above 2400 MHz increases the noise in the upper part of the spectrum slightly. The measured noise floor is higher than calculated showing the effect of man-made noise in the industrial area that was tested. Nonetheless, these noise levels are quite low due to the low noise figures and high gain of our telemetry antenna system. Absent these low noise floors, Boeing could not track its test aircraft at distances of up to 200 miles.

Appendix 1 – Measured Background Noise Data

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
8/8/2009	9:00 AM to 11:22 AM	2380-2400	LHCP	0	-142.0	180	-141.25
				10	-141.8	190	-141.5
				20	-140.8	200	-142.5
				30	-143.3	210	-143
				40	-140.5	220	-143.25
				50	-143	230	-143.5
				60	-141.5	240	-142.75
				70	-141.5	250	-140.75
				80	-142.5	260	-142
				90	-142.75	270	-141.5
				100	-141.25	280	-142.25
				110	-143	290	-142
				120	-141.5	300	-143.5
				130	-143.25	310	-143.25
				140	-143.25	320	-143
				150	-143.5	330	-141.75
				160	-142.75	340	-143.25
				170	-141.25	350	-143.5
8/8/2009	12:33 PM to 2:28 PM	2360-2380	LHCP	0	-142.8	180	-143.0
				10	-143.3	190	-141.3
				20	-143.0	200	-142.5
				30	-139.0	210	-142.3
				40	-142.0	220	-141.8
				50	-141.8	230	-142.8
				60	-142.3	240	-141.5
				70	-143.0	250	-141.3
				80	-142.5	260	-142.5
				90	-143.0	270	-142.8
				100	-142.5	280	-142.5
				110	-143.0	290	-142.3
				120	-143.0	300	-142.3
				130	-140.8	310	-143.0
				140	-143.3	320	-141.5
				150	-141.3	330	-142.3
				160	-143.0	340	-141.5
				170	-142.3	350	-141.0

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
8/7/2009	10:05 AM to 11:11 AM	2380-2400	RHCP	0	-142.3	180	-143.5
				10	-144.5	190	-143.0
				20	-142.5	200	-141.5
				30	-143.5	210	-142.0
				40	-144.3	220	-143.5
				50	-144.3	230	-143.0
				60	-144.0	240	-144.3
				70	-143.5	250	-141.0
				80	-144.0	260	-141.8
				90	-143.5	270	-144.5
				100	-143.8	280	-143.5
				110	-143.5	290	-142.5
				120	-143.8	300	-144.0
				130	-144.5	310	-144.0
				140	-141.5	320	-141.5
				150	-144.5	330	-140.0
				160	-144.0	340	-141.5
				170	-143.0	350	-144.0
8/5/2009	4:08 PM to 5:12 PM	2380-2400	RHCP	0	-143.5	180	-144.0
				10	-141.8	190	-143.5
				20	-144.3	200	-144.0
				30	-142.0	210	-144.0
				40	-143.3	220	-144.0
				50	-143.0	230	-143.8
				60	-144.0	240	-143.5
				70	-139.0	250	-143.3
				80	-143.5	260	-143.0
				90	-143.8	270	-144.5
				100	-143.8	280	-143.8
				110	-143.5	290	-142.0
				120	-142.0	300	-143.8
				130	-144.0	310	-143.5
				140	-140.8	320	-144.0
				150	-143.0	330	-139.5
				160	-142.8	340	-143.0
				170	-143.5	350	-143.0

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
8/5/2009	6:00 AM to 7:05 AM	2380-2400	LHCP	0	-140.8	180	-142.0
				10	-141.8	190	-142.0
				20	-143.3	200	-143.0
				30	-142.5	210	-142.3
				40	-141.3	220	-142.0
				50	-140.8	230	-141.3
				60	-141.8	240	-142.5
				70	-142.0	250	-142.0
				80	-141.5	260	-142.5
				90	-143.0	270	-142.5
				100	-141.0	280	-142.0
				110	-142.0	290	-143.3
				120	-143.0	300	-142.5
				130	-142.5	310	-142.5
				140	-142.8	320	-140.8
				150	-141.5	330	-144.0
				160	-143.0	340	-141.5
				170	-142.0	350	-142.5

8/4/2009	4:35 PM to 5:41 PM	2380-2400	LHCP	0	-143.8	180	-141.8
				10	-142.0	190	-143.5
				20	-142.5	200	-140.3
				30	-143.5	210	-140.8
				40	-137.5	220	-142.8
				50	-142.5	230	-141.3
				60	-140.0	240	-142.5
				70	-143.0	250	-142.0
				80	-143.3	260	-142.8
				90	-141.8	270	-142.8
				100	-142.5	280	-141.3
				110	-142.5	290	-142.0
				120	-143.0	300	-143.3
				130	-143.0	310	-143.0
				140	-143.5	320	-143.5
				150	-141.3	330	-141.5
				160	-141.8	340	-139.5
				170	-142.5	350	-144.0

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/14/2009	6:00 AM	2370	RHCP	0	-144.8	180	-145.9
				10	-145.9	190	-145.5
				20	-144.8	200	-145.0
				30	-145.9	210	-145.5
				40	-145	220	-145.4
				50	-144.7	230	-145.6
				60	-145.7	240	-145.1
				70	-145.5	250	-144.9
				80	-145.5	260	-144.5
				90	-145.8	270	-144.5
				100	-145.5	280	-144.7
				110	-144.4	290	-144.9
				120	-144.9	300	-144.4
				130	-146.2	310	-145.4
				140	-145.6	320	-145.6
				150	-145	330	-146.2
				160	-145.7	340	-144.8
				170	-146.4	350	-145.6

7/14/2009	6:00 AM	2374.5	RHCP	0	-146.3	180	-146.2
				10	-146.5	190	-145.8
				20	-146.6	200	-145.7
				30	-145.8	210	-144.9
				40	-145.7	220	-144.9
				50	-146.1	230	-144.8
				60	-146.0	240	-145.2
				70	-145.6	250	-146
				80	-146.1	260	-145
				90	-145.9	270	-146.7
				100	-146.1	280	-145.1
				110	-146.0	290	-144.9
				120	-146.6	300	-144.7
				130	-145.8	310	-144.9
				140	-145.9	320	-145.8
				150	-145.8	330	-145.1
				160	-146.4	340	-145
				170	-145.7	350	-146

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/14/2009	6:00 AM	2390	RHCP	0	-146.9	180	-146
				10	-146.3	190	-146.1
				20	-146.7	200	-146.6
				30	-146.7	210	-146
				40	-146.6	220	-146.2
				50	-146.2	230	-146.3
				60	-146.6	240	-146.8
				70	-146.5	250	-146.2
				80	-146	260	-146.2
				90	-147.1	270	-146.8
				100	-146.7	280	-146
				110	-146.6	290	-146.3
				120	-146.8	300	-146.2
				130	-147.1	310	-146.2
				140	-146.7	320	-146.3
				150	-146.4	330	-146
				160	-146.3	340	-146.3
				170	-146.7	350	-146.7

7/10/2009	7:25 AM	2370	RHCP	0	-144.74	180	-146.41
				10	-145.65	190	-145.62
				20	-146.9	200	-146.27
				30	-145.66	210	-145.34
				40	-145.42	220	-145.31
				50	-145.58	230	-145.59
				60	-146.24	240	-145.04
				70	-145.76	250	-145.38
				80	-145.64	260	-144.96
				90	-145.41	270	-145.38
				100	-145.48	280	-145.11
				110	-146.47	290	-145.31
				120	-145.8	300	-145.49
				130	-145.41	310	-145.2
				140	-145.45	320	-144.16
				150	-145.45	330	-145.3
				160	-145.34	340	-144.52
				170	-145.56	350	-146.14

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/10/2009	7:25 AM	2374.5	RHCP	0	-145.22	180	-145.06
				10	-145.26	190	-145.74
				20	-145.14	200	-145.76
				30	-145.26	210	-145.02
				40	-144.64	220	-144.81
				50	-144.89	230	-144.42
				60	-144.92	240	-145.34
				70	-145.09	250	-144.89
				80	-144.86	260	-144.83
				90	-145	270	-145.35
				100	-145.22	280	-144.7
				110	-144.99	290	-144.73
				120	-145.7	300	-144.93
				130	-144.64	310	-145.69
				140	-145.08	320	-144.84
				150	-145.16	330	-144.9
				160	-146.09	340	-145
				170	-145.09	350	-144.9

7/10/2009	7:25 AM	2390	RHCP	0	-144.75	180	-144.68
				10	-144.83	190	-145.96
				20	-144.63	200	-145.42
				30	-145.2	210	-145.88
				40	-145.33	220	-145.67
				50	-146.03	230	-144.64
				60	-145.53	240	-144.58
				70	-145.69	250	-145.67
				80	-144.79	260	-144.62
				90	-144.82	270	-143.83
				100	-144.27	280	-143.88
				110	-145.58	290	-144.71
				120	-145.94	300	-143.33
				130	-144.86	310	-145.66
				140	-144.91	320	-145.76
				150	-144.9	330	-146.08
				160	-145.58	340	-145.32
				170	-144.84	350	-144.49

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/9/2009	7:10 AM	2370	RHCP	0	-145.55	180	-145.34
				10	-145.64	190	-145.34
				20	-146.66	200	-146.02
				30	-145.44	210	-144.99
				40	-146.45	220	-146.2
				50	-145.44	230	-145.06
				60	-146.43	240	-145.02
				70	-145.53	250	-145.26
				80	-146.38	260	-145.3
				90	-146.32	270	-145.22
				100	-145.78	280	-145.22
				110	-145.11	290	-145.02
				120	-145.27	300	-145.17
				130	-145.35	310	-145.14
				140	-145.33	320	-145.04
				150	-145.1	330	-145.18
				160	-145.06	340	-145.11
				170	-145.27	350	-145.83

7/9/2009	7:10 AM	2374.5	RHCP	0	-145.08	180	-145.84
				10	-145.15	190	-145.4
				20	-145.05	200	-145.3
				30	-145.06	210	-144.94
				40	-144.19	220	-144.63
				50	-145.64	230	-145.66
				60	-144.91	240	-144.92
				70	-144.88	250	-144.77
				80	-144.9	260	-144.74
				90	-144.95	270	-144.68
				100	-145.03	280	-145.97
				110	-144.85	290	-144.54
				120	-144.64	300	-144.72
				130	-145.64	310	-144.82
				140	-144.82	320	-144.92
				150	-144.76	330	-144.74
				160	-144.92	340	-144.6
				170	-145.46	350	-144.94

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/9/2009	7:10 AM	2390	RHCP	0	-144.41	180	-144.7
				10	-145.41	190	-145.44
				20	-143.9	200	-145.24
				30	-144.22	210	-144.4
				40	-145.26	220	-144.54
				50	-144.73	230	-144.64
				60	-144.35	240	-145.76
				70	-143.74	250	-144.44
				80	-144.61	260	-145
				90	-143.89	270	-144.92
				100	-144.78	280	-144.22
				110	-144.68	290	-145.61
				120	-144.64	300	-145.3
				130	-145.46	310	-145.47
				140	-143.5	320	-144.54
				150	-145.36	330	-145.68
				160	-145.54	340	-144.4
				170	-144.53	350	-145.16

7/7/2009	8:30 AM	2370	RHCP	0	-144.4	180	-145.1
				10	-144.4	190	-144.4
				20	-144.4	200	-144.3
				30	-144.5	210	-144.2
				40	-144.2	220	-144.3
				50	-144.4	230	-143.8
				60	-144.2	240	-145.4
				70	-144.4	250	-144.3
				80	-145.3	260	-144.3
				90	-145.1	270	-144.3
				100	-145.2	280	-144.3
				110	-143.1	290	-145.3
				120	-144.4	300	-144.4
				130	-144.4	310	-145.1
				140	-144.4	320	-145
				150	-144.3	330	-144.8
				160	-144.9	340	-145.1
				170	-145.5	350	-145.4

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/7/2009	8:30 AM	2374.5	RHCP	0	-144.4	180	-145
				10	-144.4	190	-145
				20	-145.5	200	-144.1
				30	-144.5	210	-144.2
				40	-144.3	220	-144.4
				50	-144.4	230	-144.3
				60	-144.4	240	-144.3
				70	-144.3	250	-144.3
				80	-144.4	260	-144
				90	-144.4	270	-144.2
				100	-144.2	280	-144.4
				110	-145.2	290	-144.1
				120	-144.4	300	-144.3
				130	-144.1	310	-145.1
				140	-144.3	320	-144.4
				150	-144.3	330	-145.1
				160	-143	340	-144.3
				170	-145.3	350	-144.3

7/7/2009	8:30 AM	2390	RHCP	0	-144.8	180	-144.2
				10	-145.1	190	-144.1
				20	-145.7	200	-145.1
				30	-144.3	210	-145.2
				40	-145	220	-145.1
				50	-145.3	230	-145.1
				60	-145.4	240	-145
				70	-145.7	250	-145.4
				80	-145.2	260	-145
				90	-144.9	270	-144.9
				100	-144.1	280	-143.9
				110	-144.3	290	-144
				120	-144.3	300	-144.4
				130	-145.1	310	-144
				140	-144.2	320	-144.3
				150	-144.4	330	-145.2
				160	-145	340	-145
				170	-144.4	350	-145.3

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/2/2009	12:00 PM	2370	RHCP	0	-145.6	180	-144.8
				10	-144.8	190	-144.7
				20	-145.1	200	-145.2
				30	-144.7	210	-145.3
				40	-145.3	220	-144.9
				50	-144.8	230	-144.8
				60	-144.6	240	-145.2
				70	-145.2	250	-145
				80	-145.1	260	-145.6
				90	-145.1	270	-145.2
				100	-144.8	280	-144.8
				110	-145.3	290	-145
				120	-145	300	-145.5
				130	-144.7	310	-145.1
				140	-144.5	320	-145
				150	-145.5	330	-144.8
				160	-144.9	340	-145.1
				170	-145.2	350	-145.4

7/2/2009	12:00 PM	2374.5	RHCP	0	-144.5	180	-145.4
				10	-145.2	190	-145.7
				20	-144.6	200	-145.2
				30	-144.6	210	-145.2
				40	-144.8	220	-144.9
				50	-144.6	230	-144.1
				60	-145.5	240	-145.1
				70	-145	250	-145.3
				80	-144.9	260	-145.9
				90	-144.8	270	-145.4
				100	-144.6	280	-145
				110	-144.6	290	-144.8
				120	-144.9	300	-145.1
				130	-145.1	310	-145.1
				140	-144.8	320	-145.2
				150	-145.3	330	-145.3
				160	-144.9	340	-145.4
				170	-145.9	350	-144.8

Appendix 1 – Measured Background Noise Data (cont.)

Date	Time	Freq. (Mhz)	Pol.	Azimuth	Average Noise (dBm)	Azimuth	Average Noise (dBm)
7/2/2009	12:00 PM	2390	RHCP	0	-145.1	180	-145.2
				10	-145.5	190	-145.2
				20	-145.7	200	-145.4
				30	-145.4	210	-145.3
				40	-145.3	220	-145.1
				50	-145.3	230	-145.1
				60	-145.4	240	-145.2
				70	-145.7	250	-145.6
				80	-145.1	260	-145.5
				90	-145	270	-145
				100	-145	280	-145.1
				110	-144.8	290	-145.6
				120	-145	300	-145
				130	-145.4	310	-145.3
				140	-145	320	-145.5
				150	-145.2	330	-145.2
				160	-145.1	340	-145.3
				170	-145.5	350	-145.3